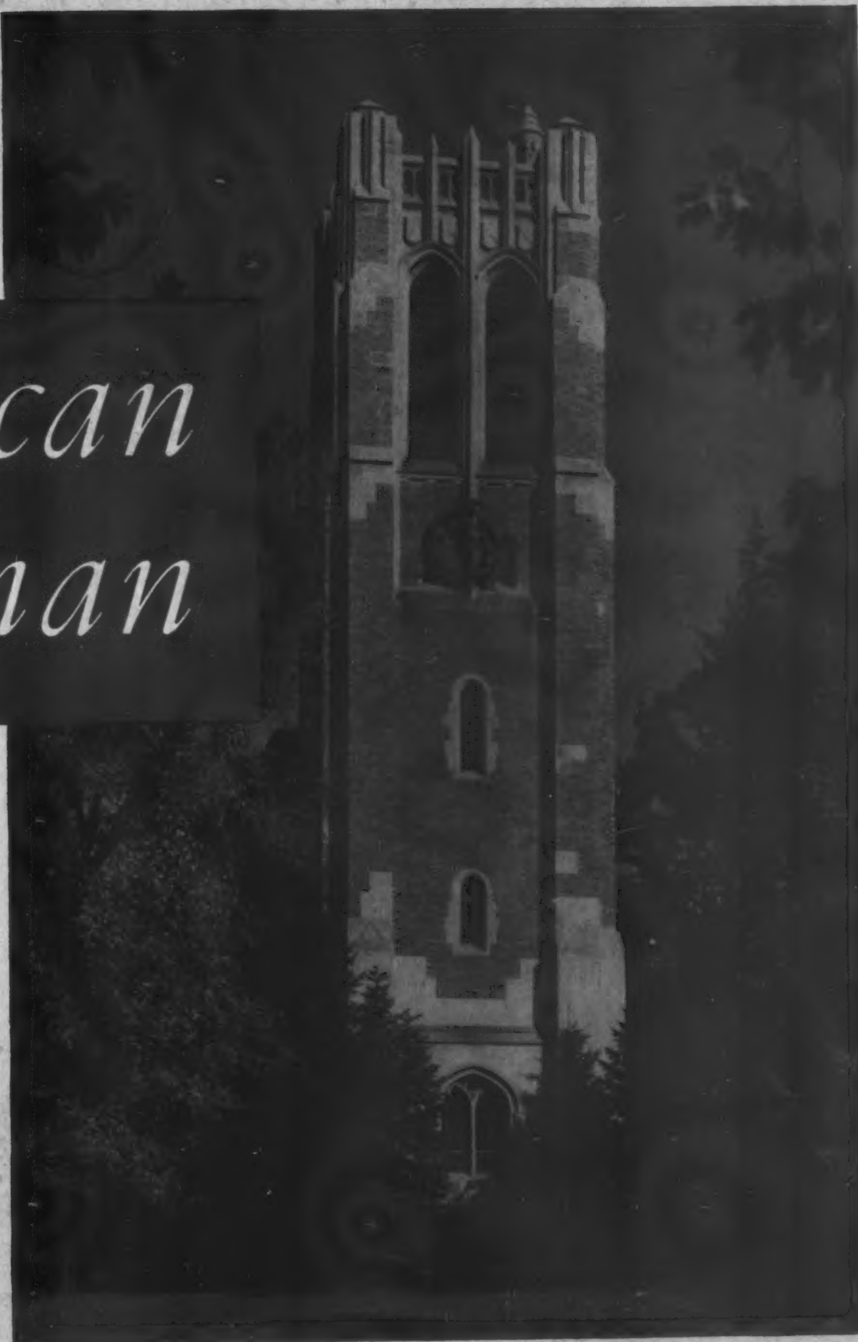
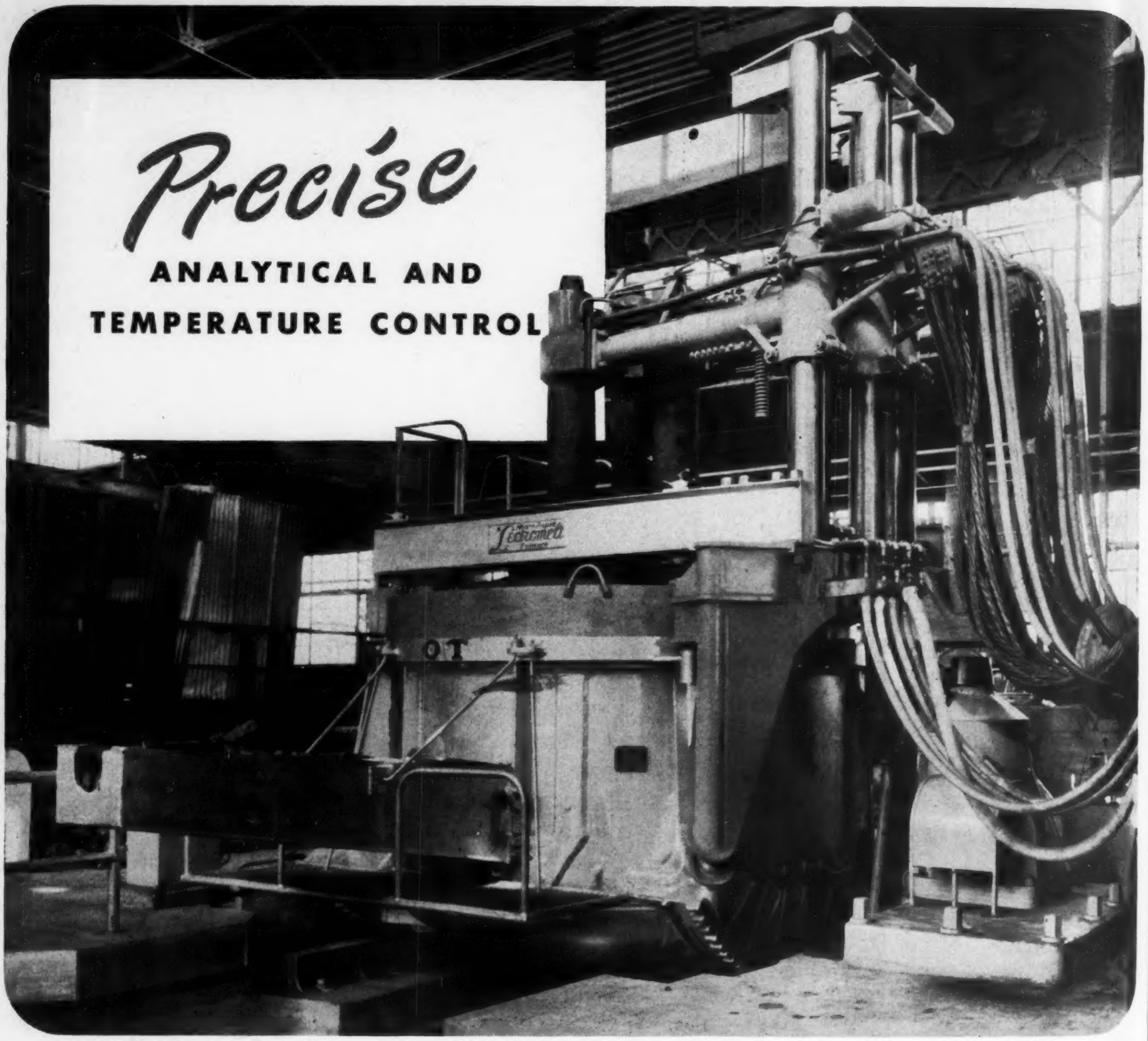
OCTOBER · 1947

American Foundryman



THE FOUNDRYMEN'S *Own* MAGAZINE . . .


Precise
ANALYTICAL AND
TEMPERATURE CONTROL

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VOLUME XII, NUMBER 4

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October, 1947

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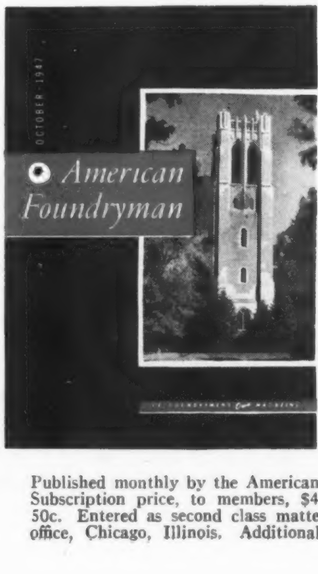

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This Month's Cover

Beaumont Tower located in the center of the campus, Michigan State College, East Lansing. Middlewestern foundrymen will gather at this college October 31-November 1 for a foundry conference (see p. 43 for program).

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facts

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PROCESS CONTROL THE BEST MEANS OF QUALITY CONTROL

Quality control, and its accompanying cost reduction, is best accomplished by instituting proper process control procedures. Conditions prevailing in industry today make it more necessary than ever before to initiate and improve control procedures and provide the necessary means for this improvement.

The writer does not presume to have all the answers to these problems, but has seen the results in improving quality and lowering cost, not only in the foundry but in many other industrial operations.

We have been striving along these lines for many years, and would like to refer to an article appearing in the SAE *Journal* of August, 1944, entitled, "Quality Control of Engineering Materials During Manufacturing and Processing." Here may be found many details for those whom we can persuade to take sufficient interest. The subject was divided into:

A. Material specifications—previous limitations and new relations to process specifications.

B. The origin and character of process specifications.

C. Organization of personnel for process specification enforcement.

D. Methods of test used to determine the effectiveness of the procedure and enforcement.

The usual methods of quality control cover material and part specifications, with checks on the finished article to see that they meet these specifications. The rejected material is then scrapped or returned for repairs. At this time, the cause of the defect is suggested and the trouble sought in the manufacturing operations. We are sure that all will agree that it is better to *keep* from making an unsatisfactory or scrap part than to *find* it after it is made and then try to locate the trouble.

Much that has been written on quality control concerns itself only with dimensions and a graphic method of recording these dimensions so that the quality, as to dimensions, and the trend of this type of quality can be easily detected. The type of quality control to which we are referring (Process Control) may be likened to preventative medical care rather than an attempt to cure the ill after we have been attacked and damage is done.

We firmly believe that millions of dollars might be saved in the foundry industry, production speeded and material conserved, by the proper use of process control. In many cases, the engineers are enthusiastic supporters of the foregoing ideas, but have difficulty in selling the ideas to top management. Therefore, here, we are addressing our remarks primarily to those in top management.

R. H. McCarroll

R. H. McCarroll, *National Director*
American Foundrymen's Association

A native of Detroit, National Director R. H. McCarroll attended and graduated from the University of Michigan, Ann Arbor, in 1914. Affiliated with Ford Motor Co. since 1915 he has held various technical positions and today is director of chemical and metallurgical engineering research. A director of the Engineering Society of Detroit and a member of the technical board of the Society of Automotive Engineers.

PHENOLIC-RESIN BINDERS

Utilization in Sand Cores for Ferrous Castings

J. E. McMillan
and
E. E. McSweeney
Battelle Memorial Institute
Columbus, Ohio

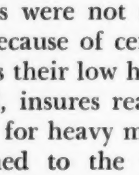
USE OF SYNTHETIC RESIN BINDERS in the heavy metal field is a comparatively recent development, although resins have had wide usage in sand casting of light metals. Thus, during the war years, the solution of difficult core binder problems for magnesium casting was found in the adaptation of ureaformaldehyde resin binders. More recently, these same resins have shown great promise in aluminum and brass founding.

Considerable work on these resin binders was done at Battelle Memorial Institute under the sponsorship of the Resinous Products & Chemical Co. and led to the development of a special core binder resin with outstanding properties, particularly in workability. More recent work has been concentrated on binders for use in heavy metal founding.

Urea resin binders were not suited for use in the heavy metals field because of certain limitations, primary among which is their low hot strength, which, in the magnesium field, insures ready collapsibility but which is undesirable for heavy metal work. Attention was, therefore, turned to the phenol-formaldehyde resins which are notably more heat resistant than the urea resins, and are the basis of the heat-resistant phenolic molded products which have been familiar for many years. These materials have already been shown, both in the laboratory and in foundry trials, to have considerable merit as core binders. Further improvements can be expected as more foundry experience is obtained and new resins are developed.

Composition of Phenolic Resins

The properties of thermosetting resins such as the phenol-formaldehyde type are so different from ordinary core binders that it will be well to consider briefly their chemical nature. They are not natural products like oil and cereal but are wholly synthetic. One of the two basic chemicals used is phenol whose structure is:

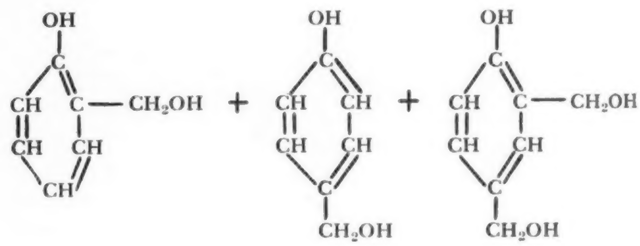


It is made by the sulphonation or chlorination of benzene and subsequent hydrolysis. Formerly most of our phenol was obtained as a by-product of coke production, but a heavy demand now requires the manufacture of large quantities of synthetic phenol.

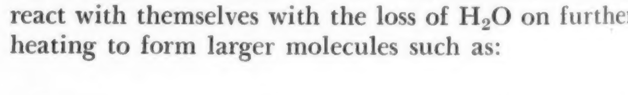
The other raw material is formaldehyde:

$$\begin{matrix} H-C-H \\ \| \\ O \end{matrix}$$

which is made from methyl (wood) alcohol, which is in turn made from carbon monoxide (CO) and hydrogen (H_2). When more than one mole of formaldehyde is reacted with one mole of phenol using alkaline catalyst, the following simple compounds are formed:



all of which are water soluble. These materials then react with themselves with the loss of H_2O on further heating to form larger molecules such as:



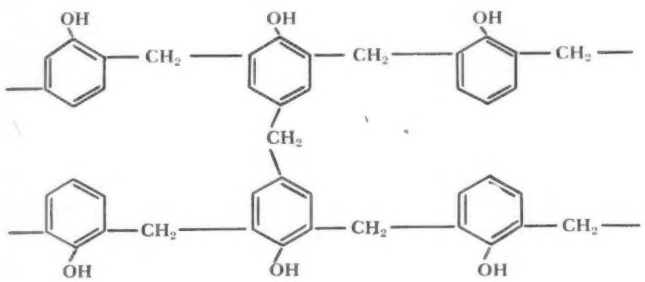
As this reaction, which is called polymerization or condensation, i.e., the union of small molecules to form large molecules or resins, progresses and the molecules become larger, the solubility of the product in water gradually decreases. For use as a core binder, the reaction is stopped by cooling while the resin is still quite soluble in water. The resin may then be used as a core binder in the form of a solution in water containing 30-65 per cent solid resin by weight.

There are, however, several objections to the liquid-type resin just described. Although the condensation reaction has been arrested, a slow reaction continues, especially during the summer season when temperatures are high. This leads to a gradual increase in viscosity of the solution and a decrease in solubility of the resin. Eventually, this reaction may progress to the point where the resin separates from the solution, gels, and is unusable. Furthermore, it necessitates the ship-

ping of large quantities of water, which is obviously uneconomical and otherwise undesirable.

These disadvantages can be overcome by removing the water from the resin. This is done by using a somewhat different resin formulation and spraying the resin solution into the top of a large tower against a stream of warm air. In this way, the water is evaporated, and the resin collected as a fine, dry powder. This powder is much more stable than the water solution. The powder may be redissolved in water to give a solution equivalent in all respects to the original solution, or may be added to the core mix in the powdered form.

Thus, either type of resin when added to the core mix is in a water-soluble form. On baking at 350 to 450 F, they rapidly condense or polymerize by loss of water, as previously mentioned, to give a cross-linked, three-dimensional structure such as:



In this form, the resin is no longer soluble in water or in organic solvents and is infusible. Actually, both an experimental liquid resin and a commercially available solid resin were used in the foundry tests.

As this point, it might be well to point out that this brief explanation of resin chemistry has been over-simplified in order to present only the essence of the nature of resins with which we will deal. To say that a certain object is made from phenolic resin is just about as descriptive to the chemist as saying to a metallurgist that an object is made of metal.

The manufacture of phenolic resins involves many factors which can change the physical and chemical characteristics of the resin. Changing any one of a number of variables such as type of reactants, catalyst, degree and temperature of reaction, and mole ratio of reactants may make a physical or chemical change in the resin even as a fraction of a per cent of an alloying element can change the nature of a steel. Hence, the possibilities of resin application in the core binder field is not limited to a single resin but extends to a large number of resin modifications. Data from several resin variations will be given in this discussion.

Physical Properties of Resin-Bonded Cores

The method of curing of resin core binders differs markedly from conventional binders, all of which require oxidation to set them. The resins, on the other hand, condense and polymerize spontaneously on heating without requiring access to the air. Therefore, even at low temperatures reaction occurs quite rapidly and the resin sets as soon as the water can be driven from the core. Uniform core is, therefore readily obtained. Furthermore, at optimum baking temperatures of 375-425 F overcure is negligible so that thick and thin core sections will have uniform strengths (Fig. 1).

The water content of resin core mixes plays a dual role in the efficient performance of the mix. As the water content increases, the strength of the core increases (Fig. 2). Below 2 per cent water, core strengths drop off rapidly. Good working strengths occur between 3 and 5 per cent moisture contents. At the same time, the rate of curing decreases as the water content increases. A rough estimate of the number of inches of cured core formed per hour is shown in Fig. 3; these data were obtained by sectioning a 6-in. cylindrical core after various baking periods.

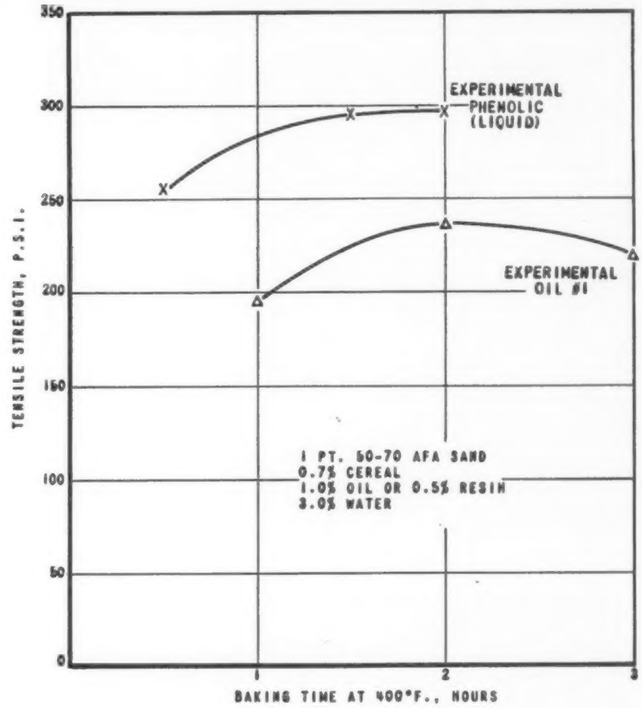


Fig. 1—Effect of baking time on core tensile strength.

Fig. 2—Effect of water concentration on oil and phenolic resin core binders.

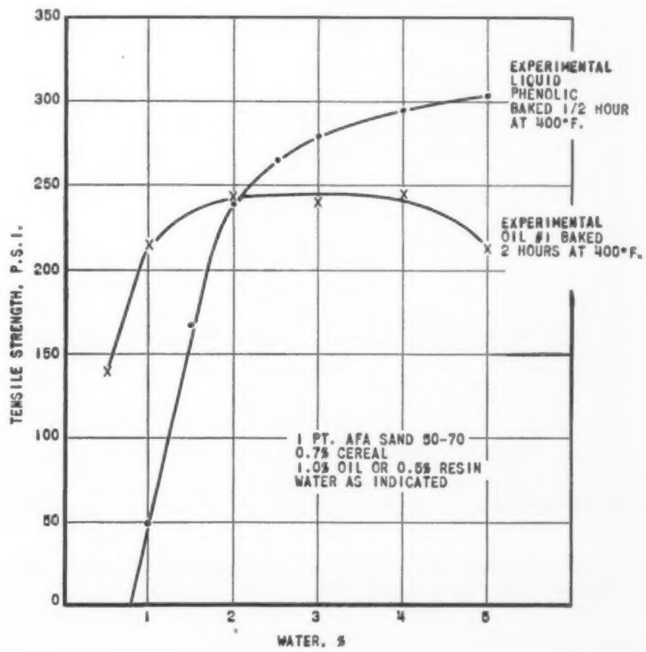


TABLE 1—FOUNDRY MIX *

Binder	Green Strength, psi	Tensile Strength, psi, Hours Baked at 400 F ½	1	3	Stickiness [4]	Dry Permeability
Liquid experimental resin [1]	0.37	354	339	309	1	235 [2]
Solid commercial resin	0.27	301	280	266	30+	223 [2]
Experimental oil No. 1	0.46	119	229	288	30+	215 [3]
Experimental oil No. 2	0.41	71	245	267	30+	226 [3]

* One pint lake sand; one pint bank sand; 1.2% oil or 0.6% phenolic resin; 0.82% cereal; 4.0% water.
[1] This mix contained 5% water.
[2] Dry permeability after 1-hr bake at 400 F.
[3] Dry permeability after 2-hr bake at 400 F.
[4] Measured by number of cores which could be hand rammed in clean core box without parting compound before sticking occurred.

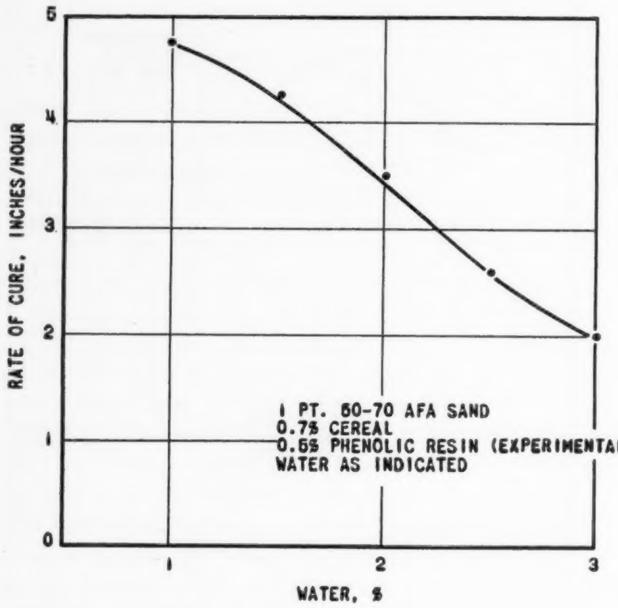


Fig. 3—Curing rates of resin-bonded cores at various water concentrations.

From these data, it would appear that the curing rate is a function of the rate of water evaporation. Since the rate of evaporation may be assumed to be the same for mixes which differ only in type of binder used, the only factor which then affects the speed of cure is the rate of polymerization. As was previously noted, the rate of polymerization of resin is extremely fast; hence a higher water concentration may be used with the resin and still have rapid cure.

Because of the inherent strength characteristics of phenolic resin binders, only about one-half the usual quantity of binder is normally used in resin core mixes to develop adequate core strength. This is illustrated by Table 1, where properties of mixes bonded with two oils, which were prepared in the laboratory for comparative purposes, and two typical resins, a liquid experimental resin and a commercial spray-dried powdered resin are given. From these data, a number of pertinent points are demonstrated.

One of the primary advantages of phenolics is their rapid baking properties. Table 1 shows that at one-half hour at 400 F the experimental phenolic has reached its maximum strength of 354 psi as compared to 119 psi for oil No. 1 and 71 psi for oil No. 2. These data are even more significant when it is noted that this resin mix has 5 per cent water in comparison to 4 per cent for the oils. Baking at 400 F causes only a slight loss of strength in the resin cores over a period of 3 hr, while at the end of 3 hr the oils are just reaching their maximum strength. The green strength of the liquid phenolic is slightly less than that of both oils.

In all cases, the dry permeability of the phenolics is equal to or higher than that of the oils. However, a major disadvantage is noticed in the liquid phenolic in that the mix is sticky and adheres to the core box. In order to overcome this disadvantage, solid phenolic resin, which was modified to overcome stickiness, was prepared. With this resin no stickiness was obtained. In overcoming stickiness by use of this modified resin, a slight loss of tensile strength and a slight decrease in green strength is observed. However, adequate strength is still obtained.

Phenolic resin binders may be used with natural clay sands but cannot be used with bentonite clays. Bentonites absorb resins and no strength results.

TABLE 2—HOT STRENGTH CHARACTERISTICS OF CORE † BONDED WITH PHENOLIC NO. 1 AND OIL NO. 1

Resin or Oil Binder	Broken After Cooling to Room Temperature, Avg. psi	Broken While Hot After Cooling to Room Temp. and Reheating 1 Hr at 220 F, Avg. psi	Each Core Broken Immediately After Removal From Oven at 450 F, Avg. psi
Liquid experimental resin	367	242 (66%)*	132 (36%)
Experimental oil No. 1	266	177 (66%)	71 (27%)

† One pint lake sand; one pint silica sand; 1.2% oil or 0.6% phenolic resin No. 1; 0.82% corn cereal; 4.0% water.

* Figures in parenthesis indicate percentage of tensile strength retained at elevated temperature conditions as compared to room-temperature tests.

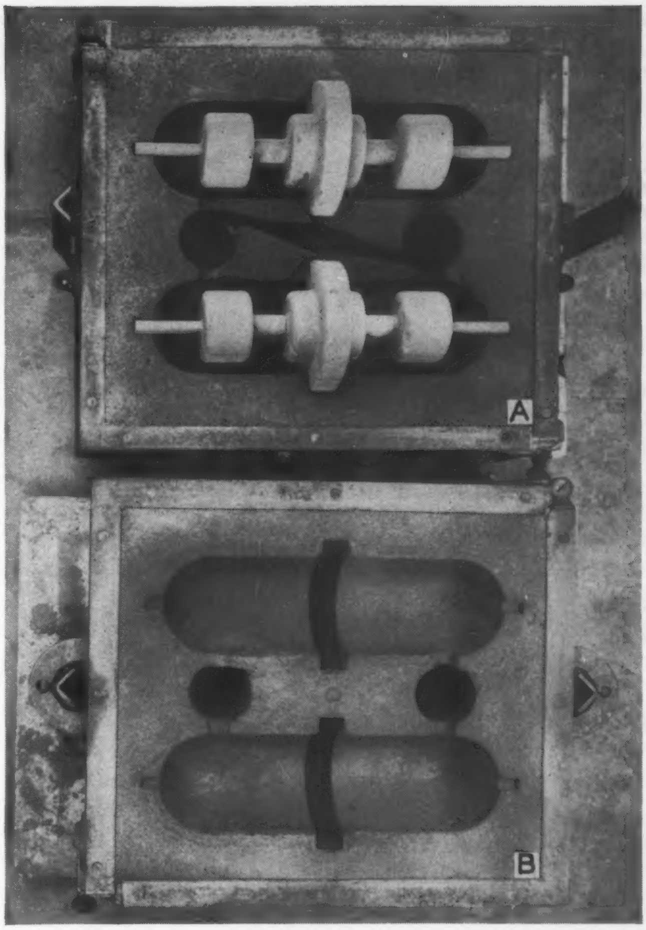


Fig. 5—(A) Drag side of mold showing placement of core. (B) Cope side showing sprue and risers.

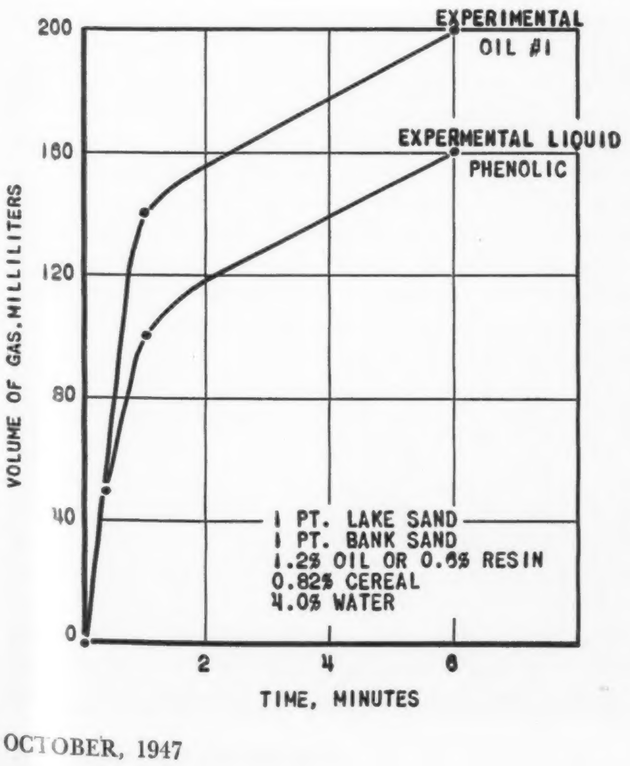
For extremely hard core surfaces, the cores may be sprayed with resin solution in the same manner as oil is used for this purpose. Another advantage of resin-bonded core mixes is their slightly better flowability in blowing machines. This advantage can increase considerably the day's production of cores.

The high heat content of gray iron which keeps the iron fluid after casting requires the use of a core which has good hot strength to prevent washing and penetration of the core. The data in Table 2 give some indication of the relative hot strengths of the liquid resin and a typical oil, although the temperatures are admittedly far below those reached in actual use. Both the phenolic and oil retain 66 per cent of their maximum strength at one elevated temperature (220 F).

When broken immediately after baking at 450 F, the resin-bonded cores had 36 per cent of their normal strength while the oil had only 27 per cent. The possibility that this greater retained strength might cause difficulties in shake-out after casting is not borne out in actual practice. No shake-out trouble was encountered in any foundry trials.

In order to determine the relative amount of gas liberated from the resin and oil cores during casting, samples of baked cores were heated in a closed tube in an atmosphere of nitrogen at 1800 F. The amount of gas evolved during the first 6 min of heating was measured. A plot of the rate of gas liberation and total amount of gas is given in Fig. 4. It will be noted that not only is the amount of gas liberated from the resin-bonded cores less than that of the oil-bonded core, but also the gas is given off more slowly than in the case of the oil-bonded core.

Fig. 4—Gas evolution for oil- and resin-bonded cores.



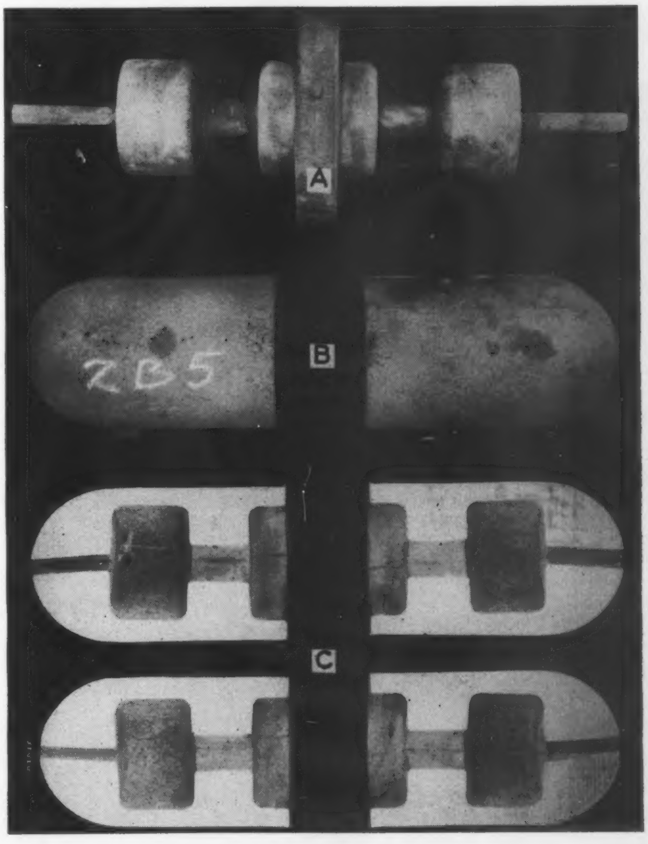


Fig. 6—(A) Sand core for foundry tests. (B) Segments cast from core. (C) Sectioned segments (core surfaces).

Table 3—Physical Test Data on Core Mixes for Battelle Foundry Tests

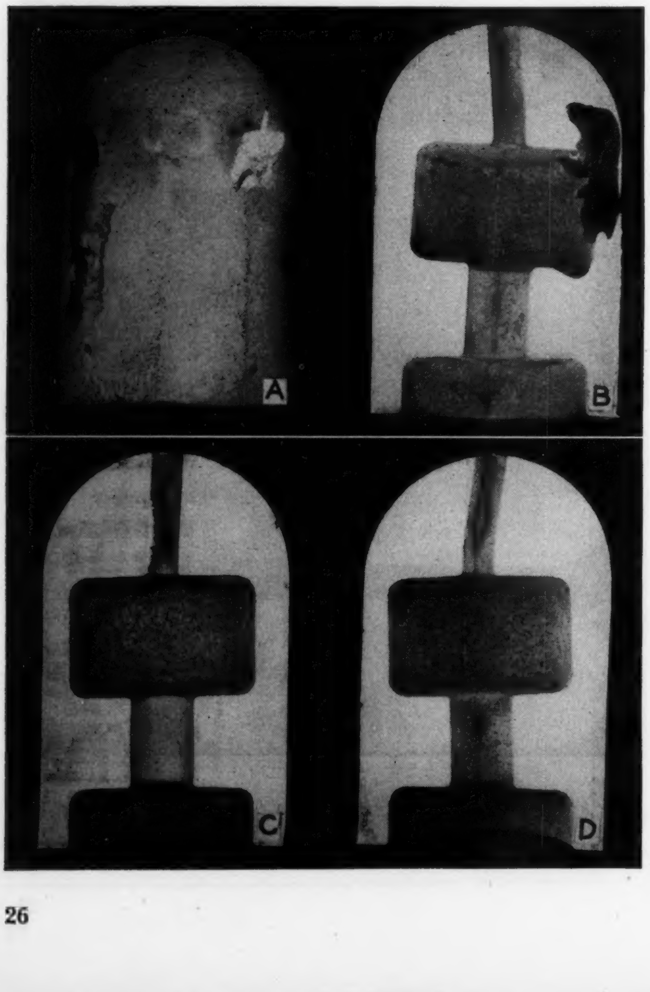
Binder	Cereal, %	Water, %	Green Strength, psi	Tensile Strength, psi Hours Baked at 450 F			
				½	1	1½	2
Experimental oil	0.7	3	0.50	88	115	200	222
Experimental liquid phenolic	0.7	3	0.38	253	276	276	261
Solid commercial resin	0.7	3	0.20	100	190	190	178
Experimental liquid phenolic	0.2	2	0.20	162	175	168	165

A program was initiated to determine the performance characteristics of resin binders under actual foundry conditions. A core was designed so that during casting it would be almost completely surrounded by metal (Fig. 5). Heavy sections of the core were given only a minimum amount of support, and print areas were made as small as possible. The cores initially were not vented. The design of the core was made as difficult as possible to use for casting so that any defects in core properties would be noted. One oil core and one resin core were placed in each mold.

The core mixes contained 0.7 per cent cereal and 1 per cent oil or 0.5 per cent experimental liquid phenolic. The water content of the mixes was held at 3 per cent (Table 3). The metal was poured at 2450 F.

Figure 6 shows a close-up of the core, the finished casting, and two sectioned castings revealing the surfaces next to the core. Figure 7 shows typical flaws which occurred in these castings. Eight of the 20 castings produced from the oil-bonded cores in the first series had blowholes. Only one of the metal segments from the resin-bonded cores had a slight blowhole or possibly "blow shrink." Both the oil and resin cores produced rough surfaces with "rat tails" in almost every casting. These defects probably are attributable to core composition rather than to any specific ingredient and could be eliminated by addition of natural clay or iron oxide.

Fig. 7—(A) Casting showing outside blowhole. (B) Casting showing inside blowhole. (C) Casting showing bad fin in section 2. (D) Badly warped casting.



Two other types of cores were tested in the same manner. One mix was of the same type as those previously mentioned except that a commercial solid phenolic resin was used. The other cores were made from a mix containing 2 per cent water, 0.2 per cent cereal, and 0.5 per cent liquid phenolic. This latter mix, which had been previously observed in laboratory experiments to give high strengths in spite of the low cereal binder and water concentration, was of particular interest because the organic gas-producing materials were reduced to a minimum.

The castings from both of these mixes were without blowholes. The surfaces adjacent to the cores were smoother than those of the first two series of castings but contained more and larger rat tails. Thus, these tests showed that difficult castings can be made with a minimum of blows by the use of resin-bonded cores. These experimental foundry results have been fairly well substantiated in commercial foundry trials.

Another advantage of resin binders is that there is an apparent chemical reaction between the phenolic resin and cereal binder in the core mix during curing. Cereal, when used with oil, causes absorption of water which weakens the core. The apparent co-reaction of phenolic resin and cereal starches reduces this tendency to absorb moisture. This advantage was qualitatively demonstrated in one foundry when two finished cores, one containing oil and the other resin binder, were buried for 24 hr in moist molding sand. On removal from the sand, the oil core was soft and wet while the resin core was still usable.

Conclusions

To sum up briefly, it has been shown both in the laboratory and in foundry trials that phenolic resins have definite advantages as core binders. (1) They give high strengths, comparable to oils. (2) They cure much faster than oils, especially in thick sections, and do not have much tendency to overcure at optimum baking schedules. (3) Their gas evolution is low as shown by laboratory determination which reduces the number of blows in casting. (4) They do not form obnoxious gases and smoking during casting.

REGIONAL CONFERENCE

AFA

Sherbrooke Meeting Well Attended

THE EASTERN CANADA and Newfoundland chapter held its Eastern Township and Regional Conference at the New Sherbrooke Hotel, Sherbrooke, Que., September 12-13. From the time the conference was opened with the registration and get together until it was closed with a golf party, the meeting was replete with interest of both a technical and social character. The splendid turnout of 163 Provincial and United States foundrymen was beyond the expectations of the conference committee.

The program of entertainment and plant visitations arranged by the Sherbrooke conference committee was quite comprehensive, while the papers read at the technical sessions covered a wide range of foundry problems.

The first paper on the program, "How to Select a Bond Clay," was read by N. J. Dunbeck, vice-president, Eastern Clay Products, Inc., Jackson, Ohio, at the conference dinner Friday evening. Chapter Chairman A. E. Cartwright, Crane Ltd., Montreal, was chairman.

The speaker enumerated the advantages and disadvantages of using synthetic sand and emphasized that one of synthetic sands outstanding features was its cost saving factor. Mr. Dunbeck also outlined the benefits derived from the three types of bonding clays: fire clay, western bentonite and southern bentonite. He also commented upon the difficulties experienced in working with the same three materials.

Prior to Mr. Dunbeck's remarks J. E. Rehder, Canadian Bureau of Mines, Ottawa, Ont., gave a short informative talk on the activities of the Bureau, referring to the numerous services available to Canadian foundries and foundrymen.

(Continued on Page 80)

Right—Telling Eastern Canada & Newfoundland foundrymen how to select a bond clay is N. J. Dunbeck. At Mr. Dunbeck's right is J. E. Rehder who had previously summarized the activities of the Canadian Bureau of Mines. Below—The "19th hole" crowd relaxing before the golf prizes were awarded.

CONTROLLING CARBON IN THE CUPOLA

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Lynchburg Foundry Co.
Radford, Va.

IT IS THE PURPOSE OF THIS PAPER to discuss some of the variables which affect carbon control when melting iron in the cupola, and to present an equation, based on a knowledge of these variables, for calculating the percentage of carbon to be expected in the iron at the cupola spout. This procedure has been used successfully over a period of several years in the foundries of the company with which the author is associated and extensive laboratory records are on file.

The ultimate objective of cupola operation covers many items. Among these is the delivery of good, hot iron to the pouring stations at a rate equal to the demands of the molding department. Another is that the iron must be of the proper composition and of the highest quality commensurate with the type of castings being produced. Good "carbon control" is one of the prerequisites for "quality control" and, in the opinion of the writer, these terms are practically synonymous, although the importance of the balance of the chemical composition must not be overlooked.

The amount of carbon in our cast irons has more influence on the physical and mechanical properties of the castings than any of the other ordinary elements entering into the chemistry of the iron. (Alloying elements and inoculants bring about certain changes due in part to their influence on the amount of graphite or combined carbon in the iron and, of course, in part to the effect resulting from being taken into solution by the matrix.)

Carbon Equivalent Calculation

One of the accepted equations for the calculation of carbon equivalent ($C.E. = \%T.C. + 0.3\ (\%Si + \%P)$) demonstrates clearly the importance attached to the percentage of total carbon in the iron. It means that the percentage of total carbon exerts about three times as much effect on the properties of the iron as do either silicon or phosphorus. In other words, the foregoing equation "indicates that a change in carbon necessitates an inverse change in silicon and/or phosphorus of approximately three times the magnitude" if we are to maintain the same structure and hardness in castings having equal cooling rates.

Furthermore, it is well known that the silicon content of our irons can be increased when necessary by the addition of ferro-silicon after the iron has been melted. Conversely, for some applications an excess of silicon (as determined by chill-test) can be compensated for by the addition of some sort of stabilizer such as ferro-chromium.

Sulphur can be increased or decreased after the metal has been melted. Manganese can be increased and likewise phosphorus if desired. In contrast with the elements just mentioned, it is practically impossible to increase or decrease the carbon content of the iron after it has been tapped from the cupola. This applies particularly to the composition range covering the bulk of our commercial gray iron castings. Furthermore, in certain applications, such as permanent mold irons, a deficiency in total carbon cannot be satisfactorily compensated for by an increase in silicon.

An excess of total carbon in these applications cannot be taken care of quickly as we have no way of reducing the carbon content; the silicon cannot be reduced and, in some of the irons in question, the addition of stabilizing alloys or inoculants is out of the question due to the detrimental effects on the finished product.

Controlling Total Carbon

In view of the foregoing it is obvious that we must make every effort to control the total carbon in the iron at the cupola spout so that it will be in the range most suitable for the castings being produced. Some of the factors which affect the percentage of carbon in the melted iron are listed in the following paragraphs.

1. *Type of Coke Used in the Cupola Bed*—Some types of coke lend themselves to greater carbon absorption by the molten metal than others. Bed height also has an effect on carbon pickup, especially in the first iron melted at the beginning of a heat, although it is assumed that the bed height has been properly and carefully adjusted in accordance with good practice.

2. *Amount and Type of Coke Used Between Charges*—As mentioned in the preceding paragraph, some types of coke lend themselves to greater carbon pickup than others. The company with which the writer is connected uses three different types of coke, either singly or in combination, to help maintain carbon control. These are by-product, beehive and pitch cokes. The by-product coke is used alone when low to medium carbon irons are being produced, and the beehive coke is used when higher carbon irons are melted. The pitch coke, all other things being equal, produces the hottest iron and results in a greater carbon pickup than is realized when using either of the other cokes. It is always

NOTE: This paper was presented at a Gray Iron Shop Course Session of the 51st Annual Meeting, American Foundrymen's Association, April 28-May 1, 1947, at Detroit.

used in combination with one of the other types, and combinations of the other cokes (without pitch) are frequently used.

3. Carbon Content of Ingoing Metal Charge—If we are to control the amount of carbon in the iron at the cupola spout we must have an accurate knowledge of the composition of the ingoing charge, including the percentage of carbon in the charge. This is easily determined provided we know the carbon content of the various components. We can and should make determinations for total carbon on each carload of pig iron received with the same care and accuracy used in determining silicon, sulphur, manganese, and phosphorus.

Likewise, we have records of total carbon in our own return scrap and gates. The use of large percentages of purchased scrap should present no particular problem as the composition, including total carbon, of the various types is quite definitely known. It is granted that carloads of mixed scrap present a problem and contents might have to be sorted according to classification. The best and simplest way to avoid these difficulties is to instruct the party responsible for the purchasing of scrap to insist that any one carload contain only one type and not a mixture of several kinds.

In comparing notes on cupola charges, foundrymen and metallurgists frequently refer to a mixture as containing a certain amount of steel, 50 per cent for example. While the percentage of steel is certainly of interest and importance, the writer feels that this figure in itself tells only part of the story because it gives no idea of the amount of carbon in the charge, and it is this figure which (as will be shown later) determines the amount of carbon in the iron at the cupola spout. To illustrate, three cupola mixtures are tabulated:

(A)	50%	steel containing	0.30%	T.C.
	50%	pig iron containing	4.20%	T.C.
		Carbon in charge	2.25%	
(B)	50%	steel containing	0.30%	T.C.
	50%	cast scrap containing	2.90%	T.C.
		Carbon in charge	1.60%	
(C)	25%	steel containing	0.30%	T.C.
	75%	cast scrap containing	2.90%	T.C.
		Carbon in charge	2.25%	

From this table it is evident that mixtures (A) and (B) will not produce irons of the same carbon content, when melted under like conditions, in spite of the fact that each contains 50 per cent of steel. Likewise, mixtures (A) and (C) will produce irons of about the same carbon content even though mixture (A) contains twice as much steel as mixture (C).

4. Accurate Weighing of Materials in Cupola Charges—If the calculation of the composition of the ingoing charge is to be of any value, we must insist that all components of the charge be carefully weighed. Weighing equipment must be checked frequently by qualified scale repair men and kept in good order. Too frequently, when the analysis "gets off," investigation reveals that the iron yard or some other scale is out of order and the charge has been estimated.

The weighing equipment must be rugged and accurate, sensitive over the range in which it is to be used, and intelligently chosen for the job it is intended to do. Generally speaking, one set of scales will not be satisfactory for weighing all of the materials entering into the charge. For example, 50 lb of 50 per cent lump ferro-silicon ordinarily cannot be weighed accurately on a set of scales designed for heavy loads and where

Views showing cupola charging method; accurate weighing (below) of cupola charge components and (left) method of conveying charge to cupola.

the smallest division on the dial represents 25 lb and the tare weight of the charging car and bucket may be 3,000 or 4,000 lb.

Assuming that the scaleman works to an accuracy of plus or minus one division on the scale dial, his error could then be plus or minus 25 lb. This represents 12.5 lb of silicon, which in turn means a possible variation of 0.50 per cent silicon in a 2,000-lb charge. This is not a hypothetical case as these figures represent a set of conditions which actually exist at one of this company's plants. For weighing materials used in quantities up to about 50 lb an ordinary spring scale has been found to be quite satisfactory.

Silicon Variations

Reference has been made here to the possible variation of percentage of silicon in the iron resulting from inaccurate weighing of ferro-silicon, and the reader may well ask what bearing this has on carbon control. It is well known that, all other things being equal, the carbon pickup during melting will be inversely proportional to the percentage of silicon present in the iron at the cupola spout. This will be discussed in more detail later in the paper.

For weighing 100 or 150 lb of silvery pig iron a portable platform scale of 500-lb capacity is used. Coke is weighed on the same type of scales and the equipment need not be expensive or elaborate. Containers used for coke may be scrap steel drums cut in two with handles welded to each half. The gross weight is marked on each container and, for convenience and ease of handling, the coke is weighed in batches of 100 lb or less. Plant layout and conditions will determine, at least to some extent, the type of weighing equipment to be used. However, this subject should be given considerable thought and attention as there is no substitute for accuracy in making up cupola charges.

5. Tapping Technique—All of the cupolas operated by this company are of the front-slagging type which, of course, means that iron flows from the taphole continuously from start to finish of the heat. At no time is there any appreciable accumulation of molten iron in the well of the cupola, but the small amount which does collect remains at a constant level because it flows out as fast as it is melted. Front-slagging cupolas possess many advantages over those tapped intermittently, including uniform carbon pickup, which is one of the essentials of carbon control.

Front-Slagging Cupolas

Other advantages include hotter iron at the cupola spout; no need for a slag hole with the usual loss of blast and occasional shutdowns for making repairs, flow of metal from the cupola may be stopped by shutting off the blower, thus eliminating the need for "bots" in the breast hole. This not only makes a safer operation, but also it is practically impossible to run cupola slag into the pouring ladles, as frequently happens when the man tapping the cupola leaves the breast hole open a little too long or a bot accidentally comes out.

In cupolas which are tapped intermittently the amount of molten iron in the well may range from several tons (in the larger cupolas) to practically none in the few minutes required to make a tap. This means that the depth of iron within the cupola is constantly changing, and under these conditions the carbon pickup is apt to be less uniform than when the metal is removed as fast as it is melted.

It is not inferred that uniform carbon pickup in the cupola cannot be obtained with intermittent tapping, but it requires a little closer supervision. An exact tapping cycle must be established, and the time between taps must then be maintained by means of a stop watch.

Frequently, with intermittent tapping, a cupola tapper can see no harm in allowing the time between taps to vary 10, 20 or 30 seconds, although actually this may be a high percentage of the established time cycle (between taps), and variations of the magnitude just mentioned may materially affect the percentage of total carbon in the iron tapped, especially in mixtures containing high percentages of steel.

6. Other Factors—Generally speaking, any change made in the operation of the cupola which results in higher metal temperatures at the cupola spout will result in somewhat higher total carbon in the iron. These changes include an increase in coke between charges (reducing coke ratio), increasing blast pressure with attendant increase in melting rate and temperature, preheating the cupola blast, and others.

Weighing Blast Air

Accurate weighing of the air used for the blast is another essential to good carbon control. It is well known that for every pound of iron melted, practically one pound of air is required. It therefore seems logical that a raw material used in quantities nearly equal in weight to the tonnage of iron melted be metered or weighed with the same care as the metallic components of the charge. Variations in the weight of air blown into the cupola will affect melting rate and melting temperature, and these variables will in turn affect carbon pickup, as discussed in the preceding paragraph.

Conditions within the cupola must be kept as uniform as possible from day to day as well as throughout the duration of a single heat. Moisture content of the blast has its effect on carbon in the iron at the cupola spout, a low moisture content resulting in higher carbon than a high moisture content, all other things being equal. It is well known that the moisture content of the blast may vary from 2 grains per cu ft to 12 grains per cu ft, depending upon conditions as well as the season of the year. Furthermore, the moisture may vary within the limits referred to during the course of a single day's operation.

There are 7,000 grains in one pound. Now let us consider the possible variation in the amount of water carried into a cupola with the air blast when melting 200 tons per day, as is often the case at one of the foundries being discussed. This operation will require about 5,200,000 cu ft of air, so that the water blown into the cupola will be between 1,500 lb (180 gal) and 9,000 lb (1,080 gal).

From these figures it is evident that the control or elimination of a variable of such magnitude is well worth consideration. For this reason equipment for controlling moisture in the cupola blast was installed at one of the plants of the company.

The installation is designed to remove moisture from

13,000 cu ft of air per minute down to 4 grains per cu ft in the summer season, and also is capable, in dry weather, of introducing as much as 7 grains per cu ft. In the winter season it is necessary to add moisture to the cupola blast in order to maintain a year 'round constant control.

While it so happens that this company has installed a moisture control system for maintaining a year 'round uniform moisture content of 4 grains per cu ft of cupola air blast, this figure in itself is not particularly significant. Whether the system be designed for 2 grains or 5 grains or any other figure, the significant feature is that variations in moisture content of the cupola blast have been eliminated.

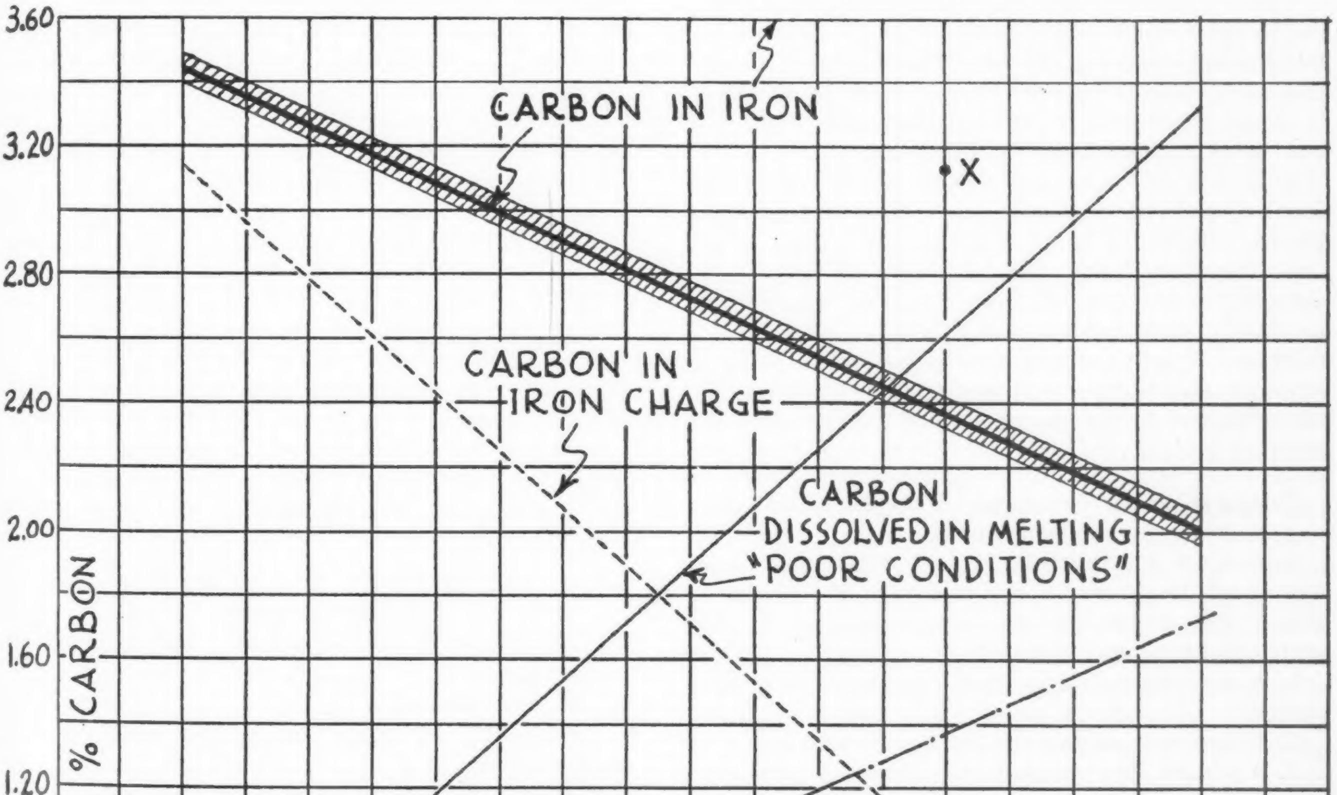
The balanced blast type of cupola helps to maintain good uniform conditions within the cupola from start to finish of the heat, and is particularly helpful when the heat is of long duration. Five of the seven cupolas operated by the company are of the balanced-blast type, each equipped with one row of main tuyeres and two rows of auxiliary tuyeres. The main tuyeres are provided with slide valves so that they may be opened or closed at will during the course of the heat.

Two of the main tuyeres diametrically opposite are closed at the same time so that the area directly in front of them is heated to a temperature sufficiently high to melt off all overhanging slag. After 8 or 10 min these are opened and two others are closed. This procedure is continued throughout the heat, and results in the prevention of bridging and blocking-up of the main tuyere openings.

The openings of the auxiliary tuyeres are adjustable, but the settings cannot be changed without shutting off the cupola blast. The upper, or auxiliary tuyeres, bring about more complete combustion of the coke and thereby make possible a more efficient cupola operation, and in conjunction with the controllable main tuyeres the balanced-blast cupolas melt somewhat faster and at higher temperatures with the same coke ratios than the cupolas provided with conventional tuyeres.

Auxiliary cupola equipment plays an important part in control and uniformity of the molten iron. All cu-

Fig. 1—Graph showing method for determination of percentage of carbon in iron.



polas in this company's foundries are charged mechanically. Mechanical charging usually improves the operation because it is easier to keep the cupola filled to the charging door level at all times during the melting operation, and the types of charging equipment used distribute both the metal and coke in the cupolas in a much more satisfactory manner than is accomplished by hand.

This is especially true with cupolas of larger inside diameters, where charging crews often are prone to place the heavier components of the charge near the charging door opening. In hot weather more of the coke charge than should be is placed near the charging door in order to protect the "chargers" from heat inside the cupola.

As previously stated, all of the cupolas operated by the company are of the front-slagging type. Molten iron from the cupolas runs directly into forehearths or teapot ladles, where an amount equivalent to several cupola charges is stored and mixed, resulting in greater uniformity of metal composition than would be obtained when tapping directly from the cupola into the pouring ladles.

This is especially true when the capacity of the pouring ladles is small (1,000 lb or less). The size of the forehearth ladle is such that it will hold as much molten iron as the cupola melts in 10 to 15 min. From this it is obvious that different sizes of forehearth ladles are used with cupolas of different capacities.

After having taken into account all of the factors involved and eliminating as many variables as is possible the laboratory should keep proper records of all cupola mixtures used. They will in time become invaluable to the operator in making up mixtures to produce irons of predetermined carbon content and, furthermore, will enable him to make a graph or series of graphs showing the total carbon level to be expected in the iron at the cupola spout when the carbon in the charge is known.

Computations for Percentage of Carbon in Iron at Cupola Spout

Some years ago, Donald J. Reese* prepared an excellent graph for determining percentage of "carbon in iron." The graph (private communication) is presented as Fig. 1 and includes:

1. A line representing "per cent steel in cupola charge."
2. A line representing "carbon in iron charge."
3. A banded line representing "carbon in iron."
4. A line representing "carbon dissolved in melting under ideal conditions."
5. A line representing "carbon dissolved in melting under poor conditions."
6. In the area above the banded line representing "carbon in iron" Mr. Reese has located a point "X" which, of course, represents an unknown percentage of "carbon in iron." In other words, when melting under poor conditions it will be impossible to predict with any degree of accuracy the carbon to be expected in the iron at the cupola spout, as it may fall at any point "X" within the area in question.

* Development and Research Div., International Nickel Co., Bayonne, N.J.

Mr. Reese's graph presents valuable information regarding the relationship between carbon content of the molten iron and carbon content and steel content (percentage) of the charge.

Records have been kept in the laboratories of the Lynchburg Foundry Co. over a period of more than 10 years in which the effects of changes in percentage of ingoing carbon, various percentages of silicon and phosphorus, as calculated in the iron at the cupola spout, and the effects of various types of coke and/or combinations have all been noted. From the data gathered it has been possible to derive an equation and draw a graph (Fig. 2) from which "per cent carbon in iron at cupola spout" can be predicted when "per cent carbon in cupola charge" is known regardless of the relative amounts of steel, cast scrap, and pig iron used in the charge. Certain conditions must exist and certain practices must be followed in order that data taken from the graph be reliable. They are as follows:

1. Use of by-product coke.
2. Continuous flow of metal from cupola (front slagging), or
3. Maximum tapping cycle of 90 sec if tapping intermittently. This means 90 sec from the time any one "bot" is removed from the breast until the next one is removed. It does *not* mean that the cupola is left closed up for 90 sec after the "bot" is put into place. Obviously, this means that study must be given to calibration of the tap hole as iron must be removed from the cupola just about as fast as it is melted.
4. Silicon at cupola spout must be about 2 per cent.
5. Phosphorus in iron at cupola spout must be about 0.2 per cent.
6. The graph has been used successfully for "calculating" carbon in iron at the cupola spout within the range of 2.40-3.60 per cent T.C. This, of course, means that carbon in cupola charge was in the range of 1.10-3.50 per cent.

In Fig. 2, the carbon content of the cupola charge is plotted against carbon content of the molten iron at the cupola spout. The equation for this relationship is as follows:

(1) $\text{T.C. (spout)} = K + \frac{1}{2}\ (\%\ \text{C in charge} - 2.00\%)$, where

"T.C. (spout)" means "per cent carbon in iron at cupola spout."

"K" is a constant.

"Per cent C in charge" means "per cent carbon in cupola charge."

For the graph drawn a value of 2.85 per cent has been assigned to K, and this value applies when the six conditions described exist in the foregoing. The equation then becomes:

(2) $\text{T.C. (spout)} = 2.85\% + \frac{1}{2}\ (\%\ \text{C in charge} - 2.00\%)$.

The portion of the graph (Fig. 2) representing the range over which it has been used successfully is drawn as a band indicating that the carbon in the iron at the cupola spout can be expected to fall within a range of approximately plus or minus 0.05 per cent.

The graph is used as follows: Suppose the carbon in the charge has been calculated and found to be 2.00 per cent. A horizontal line is drawn intersecting the

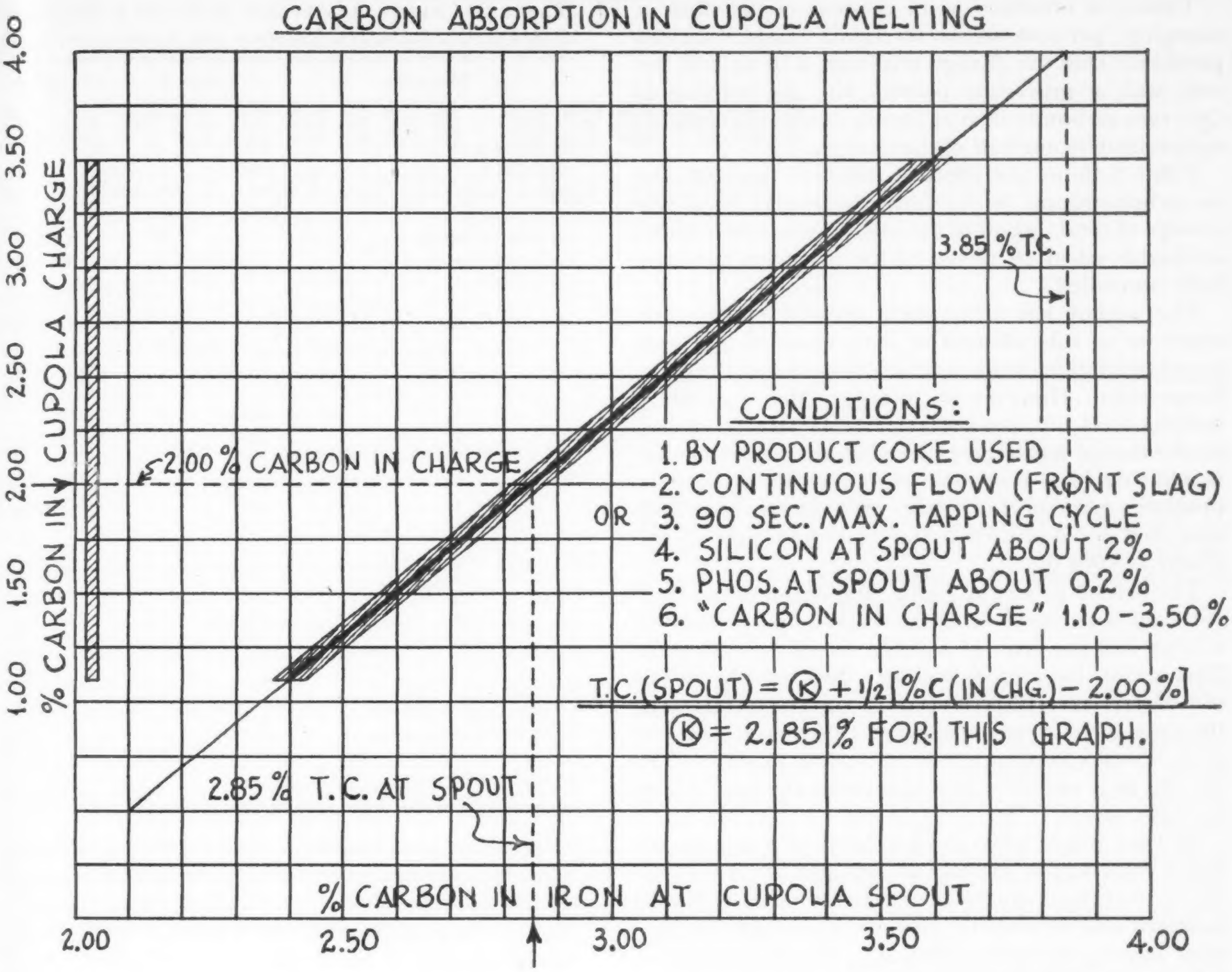


Fig. 2—Graph showing percentage of carbon in iron at cupola spout when percentage of carbon in charge is known and certain conditions exist.

graph at the level representing "2.00 per cent carbon in cupola charge." From the intersection with the graph a vertical line is drawn so as to intersect the line representing "per cent carbon in iron at cupola spout." This point is found to be 2 .85 per cent, or the percentage of carbon in the iron at the cupola spout.

Examination of the graph and/or Equation (2) reveals the following:

1. When the "per cent carbon in the charge" equals 2.00 per cent, the "per cent carbon in iron at cupola spout" will equal 2.85 per cent, or K.
2. Any change made in "per cent carbon in the charge" increases or decreases the "per cent carbon in iron at cupola spout" by an amount equal to one-half of the change.
3. Within the range of the graph, it is noted that there is always an increase in carbon during melting.
4. Beyond the range of the graph (where we have no data at present) it seems probable that when the "per cent carbon in the charge" is 3.70, the "per cent carbon in iron at cupola spout" will likewise be 3.70, indicating that there is no carbon pick-up at this point. When the "per cent carbon in the charge" exceeds 3.70, it seems probable that there will be a reduction or loss in carbon during the melting operation. For example, when the ingoing carbon is 4.00 per cent, it appears that the carbon in iron at cupola spout" will be 3.85 per cent.

Attention is again called to the practices and conditions under which Equation (2) holds. If there is a change in these conditions a modification is necessary. For example, if silicon in iron at cupola spout is more or less than 2 per cent, calculation for the effect on total carbon is made as follows: Subtract silicon in iron at cupola spout from 2.00 per cent. Multiply this difference by 0.25 and add the product to the percentage of carbon expected in iron at the cupola spout.

Example 1—Suppose silicon in iron at cupola spout is 1.60 per cent. Then 2.00 per cent — 1.60 per cent = 0.40 per cent. The product of $0.40 \times 0.25 = 0.10$ per cent, which is the amount to be added to the percentage of carbon expected in iron at the cupola spout.

Example 2—Suppose silicon in iron at cupola spout is 2.40 per cent. Then 2.00 — 2.40 = minus 0.40 per cent. The product of minus $0.40 \times 0.25 =$ minus 0.10 per cent, which is the amount to be added, but adding a minus quantity, of course, means that its numerical value is subtracted. This relationship has been found to be quite accurate when silicon in iron at cupola spout is within the range of 1.50-2.50 per cent. The effect of phosphorus is handled the same way in quantities up to 0.60 per cent phosphorus in iron at the spout of the cupola.

Table 1 is presented as an example of the effect of changing "per cent carbon in cupola charge." In this particular case the change was from 2.36 to 2.62 per cent and, as previously pointed out, the increase in "per cent carbon in iron at cupola spout" was equal to approximately one-half of the change.

Table 2 shows the effect of different types of coke on carbon pickup. It also shows the uniformity of percentage of total carbon in the iron in consecutive ladles attainable when all phases of the operation are carefully controlled.

The author has deliberately avoided making any reference to coke charges or coke ratios as any such recommendations might lead to difficulties in the cupola operation. However, let us assume that a cupola is melting good, hot iron and at the same time the carbon in the charge is 3.00 per cent. Let us assume further that the operator is at some other time called upon to produce a grade of iron calling for a charge containing only 2.00 per cent carbon and that the weight of the charge is 4,000 lb.

The carbon picked up by the first charge mentioned will be 0.35 per cent, while that picked up by the other will be 0.85 per cent, or a difference of 0.50 per cent. This means that a 4,000-lb charge with ingoing carbon of 2.00 per cent will pick up 20 lb more of carbon than the same size charge with ingoing carbon of 3.00 per cent. Twenty lb of carbon is equivalent to about 22 lb of coke, so it would be wise to increase the coke charge by this amount.

In other words, when using a charge of such a nature that a considerable amount of carbon is absorbed during the melting operation, care must be taken to supply sufficient coke to properly melt and superheat the iron, after having made due allowance for the equivalent amount absorbed by the charge.

Under certain conditions the cupola practice may be deliberately manipulated to bring about some desired result. The use of beehive coke alone or in combination with pitch coke is a deliberate manipulation intended to produce irons higher in total carbon content than could be obtained when melting the same charge with by-product coke alone. In other instances, a combination of by-product and pitch coke is used to melt charges having a lower percentage of carbon in the charge than would normally be used when melting with by-product coke alone.

It may be of interest to note that in the author's experience, when using "good" coke, any manipulations of the sort referred to have always resulted in an increase in the value of "K" in the equation. On the occasions when there has been a decrease in the value of "K," it has almost always been traceable to the use of coke not intended primarily for cupola use. This we have referred to as "bad" coke. In conclusion, the author wishes to point out that the equation

$$\text{T.C. (spout)} = 2.85\% + \tfrac{1}{2}\ (\%\ \text{C in charge} - 2.00\%)$$

is a good yardstick for the measurement of coke quality, although a discussion of this subject is beyond the scope of this paper.

It is realized that Equation (2) as presented herein is not in its simplest form. It could be written as follows:

$$(3)\quad \text{T.C. (spout)} = 1.85\% + (0.5)\ .\ (\%\ \text{C in charge}).$$

Furthermore, it would probably be well to introduce a "coke" factor "f" and assign to "f" a value of one (1) for what we consider "good" coke (or a combination of cokes), a value greater than one (1) for "extra good" coke, and a value less than one (1) for "bad" coke. The equation would then be written:

$$(4)\quad \text{T.C. (spout)} = 1.85\% + (f)\ .\ (0.5)\ .\ (\%\ \text{C in charge}).$$

Table 1—Carbon Absorption in Cupola Mixtures—Effect of Changing Percentage of Carbon in Charge
(by-product coke used for melting)

Materials	Charge No. 1 lb	Charge No. 1 %	Charge No. 2 lb	Charge No. 2 %
Malleable pig	300	15.0	300	15.0
Automotive cast	700	35.0	900	45.0
Cast iron scrap (domestic)	250	12.5	250	12.5
Steel scrap	530	26.5	375	18.8
Silvery pig	100	5.0	75	3.7
Manganese steel	120	6.0	100	5.0
Totals	2000	100.0	2000	100.0
Carbon in charge		2.36		2.62
Coke per charge (by-product)	300		300	
Coke ratio	6.7:1		6.7:1	
Carbon in iron	3.05-3.20		3.20-3.35	
Carbon at cupola spout	Avg. 3.13		Avg. 3.28	

(A) Difference between carbon in charges No. 2 and No. 1 equals 2.62 minus 2.36 or 0.26 per cent.

(B) Difference between avg. carbon in iron at cupola spout in charges No. 2 and No. 1 is 3.28 minus 3.13 or 0.15 per cent, approx. one-half of difference in (A) above.

NOTE: Silicon in both charges was adjusted to 1.70 per cent at cupola spout by means of 50 per cent ferro-silicon.

Table 2—Carbon Absorption in Cupola Mixtures—Comparison Between Beehive and By-product Cokes

Materials	Charge A lb	Charge A %	Charge B lb	Charge B %
Silvery pig (8% Si)	100	5	100	5
Steel No. 2	1000	50	800	40
Motor blocks	900	45	1100	55
Totals	2000	100	2000	100
Carbon in charge		1.72		2.01
Coke per charge	250 (Beehive)		250 (By-prod.)	
Coke ratio	8:1		8:1	

Total Carbon in Melted Iron Samples Taken From Consecutive Ladles of 2 Tons

Ladle No.	T.C., %	T.C., %
1	3.04	3.00
2	3.06	3.04
3	3.02	3.04
4	3.02	3.04
5	3.05	3.08
6	3.04	3.08
7	3.04	3.02
8	3.00	3.02
9	3.04	3.08
10	3.06	3.08
11	3.06	3.06
12	3.06	—
Average	3.04	3.05
Carbon pickup per ton	26.2 lb (1.31%)	20.0 lb (1.0%)
Coke melting ratio	9.0:1	8.7:1

NOTE: Silicon in both charges was adjusted to 1.50 per cent at the cupola spout.

MANGANESE BRONZE
Conditions Influencing Segregation

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Under some conditions, manganese bronze melts contain a sludge consisting of iron, silicon, aluminum and manganese. Formation of the sludge is associated with silicon contents in excess of 0.1 per cent. There is a tendency for elongation to decrease as silicon increases. The sludge will cause misruns in thin-walled castings.

THE FOLLOWING INCIDENT called attention to the effect of small amounts of impurities in manganese bronze.

In pouring several molds from the same ladle of molten manganese bronze, the molder noted that the metal seemed to cool faster than usual. He also noticed a tendency toward formation of a sludge, which floated in the metal. It was assumed that the furnaceman had not brought the metal up to the desired temperature, but he insisted that he had done so. Pyrometers were checked and found to be in order. Several days later the same thing occurred again, and once more the temperature was checked and found to be as ordered. An analysis of the metal showed that it conformed to required specifications. When some of the floating sludge was analyzed, it was discovered to be higher in iron and silicon content than the original metal. These questions immediately arose:

What part, if any, did the silicon play in the formation of the high iron sludge?

What amount of silicon can be tolerated, with no detrimental effect?

What is the source of the silicon contamination?

Test Procedure

In testing to locate the source of the silicon contamination, ingots from several shipments of manganese bronze were sectioned. The section surfaces were prepared for macroetching by grinding on a 230 grit belt. The surfaces were then etched in a 10 per cent ammonium chloride solution for two weeks. By that time rusty colored patches had developed on the surfaces, where there were local segregations of iron.

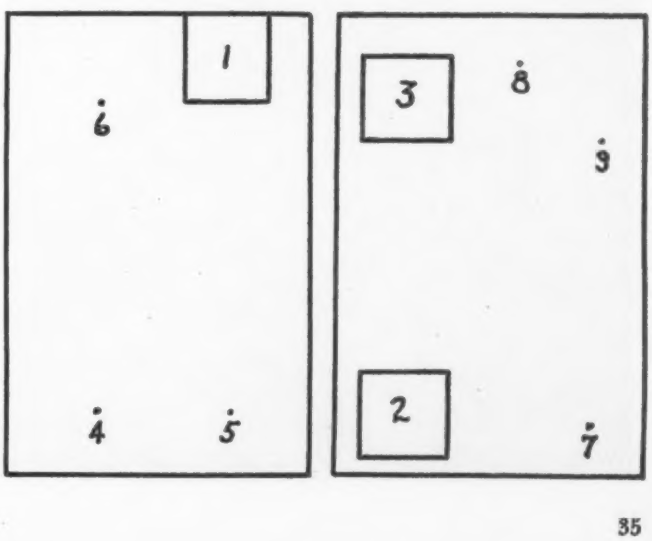
In Fig. 1 are photographs, at two magnifications, of two ingot sections etched for two weeks in a 10 per cent ammonium chloride solution. A shows no evidence of iron segregation and was the best lot of ingot examined. B shows a marked segregation toward the top of the ingot; it was the worst lot of ingot examined. Other ingot shipments ranged between.

From the sections shown in Fig. 1 samples ½ x ½ in. were taken for microscopic examination and chemical analysis. Figure 2 shows the location from which the samples were taken.

Figure 3A, location A1 of Fig. 2 at 100 magnifications, shows a beta-structured manganese bronze with the iron compound well distributed. Figure 3B shows the same location at 500 magnifications. Note that the areas around the large iron compound segregations are largely free of the small iron compound segregations. Table 1 gives the average analysis of this section, sample number 2A1.

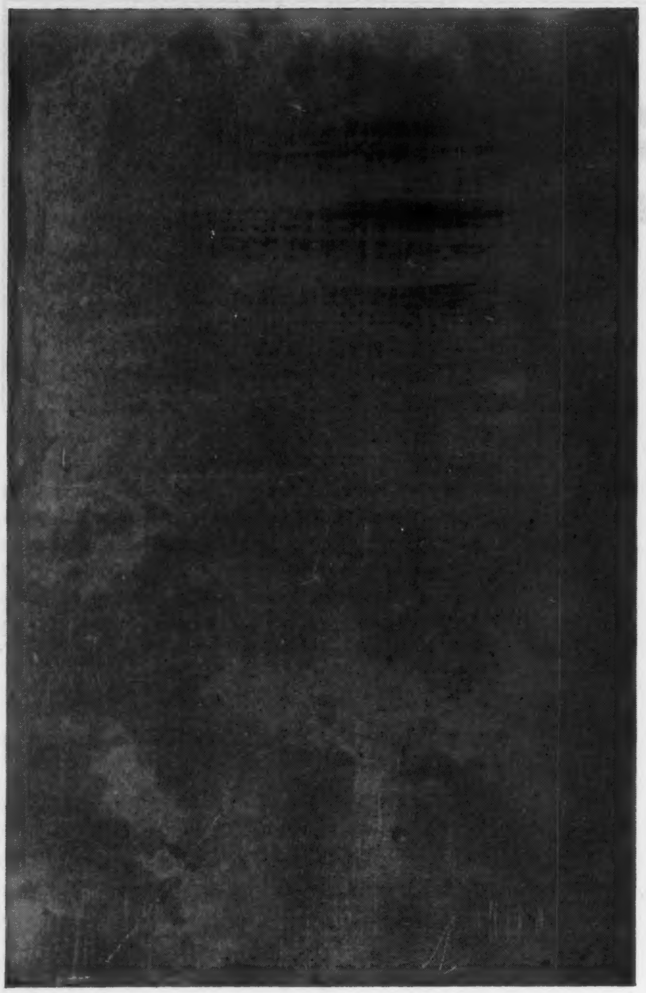
Figure 4A, location 2B of Fig. 2, at 100 magnifications, shows an alpha beta structured manganese bronze, with the iron compound well distributed. Figure 4B shows the same location at 500 magnifications. Table 1, under sample number 2B2, gives the average analysis of this section.

Fig. 2—Sketch of ingot sections, A, left and B, right, shown in Fig. 1, showing location of chemical, spectrographic and microscopic samples. Numbers 1, 2 and 3 are the microscopic and chemical samples. Numbers 4, 5, 6, 7, 8 and 9 are the spectrographic spark locations.



NOTE: This paper was presented at a Brass and Bronze Session of the 51st Annual Meeting, American Foundrymen's Association, at Detroit, April 28-May 1, 1947.

* The opinions or assertions contained herein are those of the writer and are not to be construed as official or revealing the views of the Navy Department or the Naval Service at large.



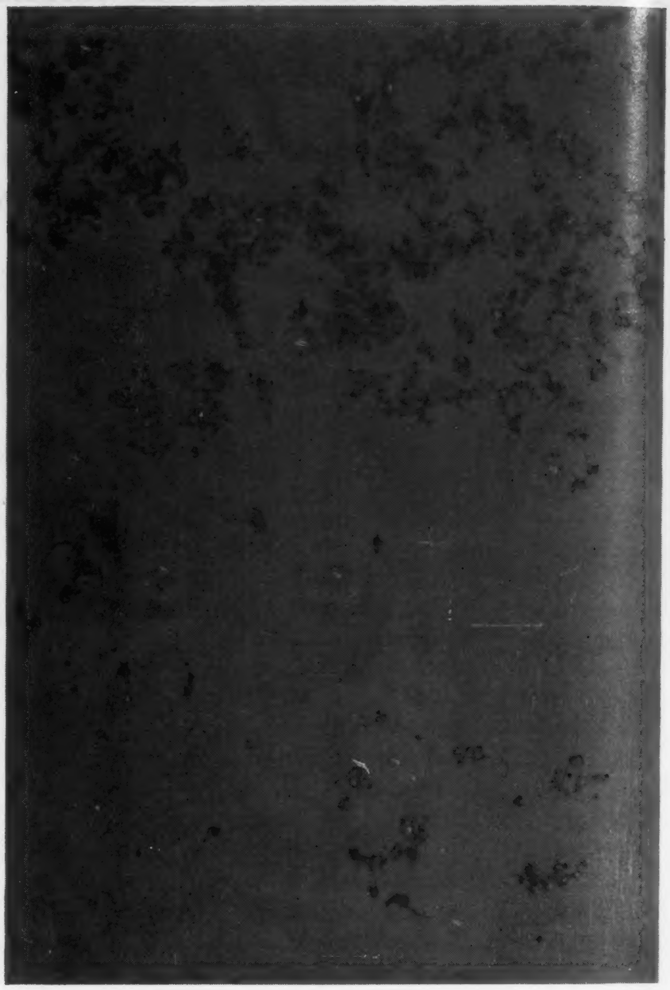
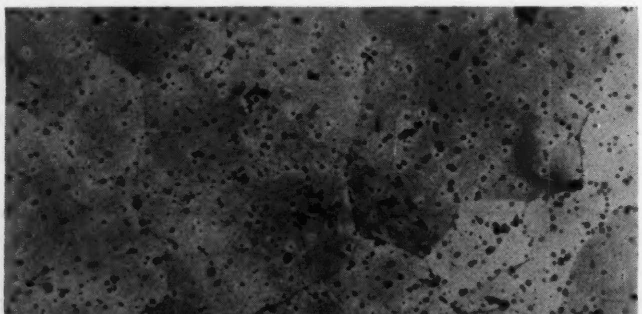
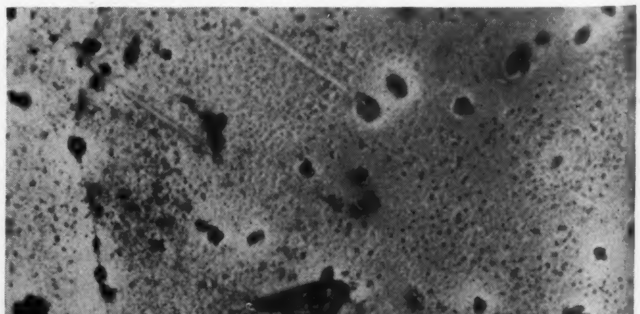
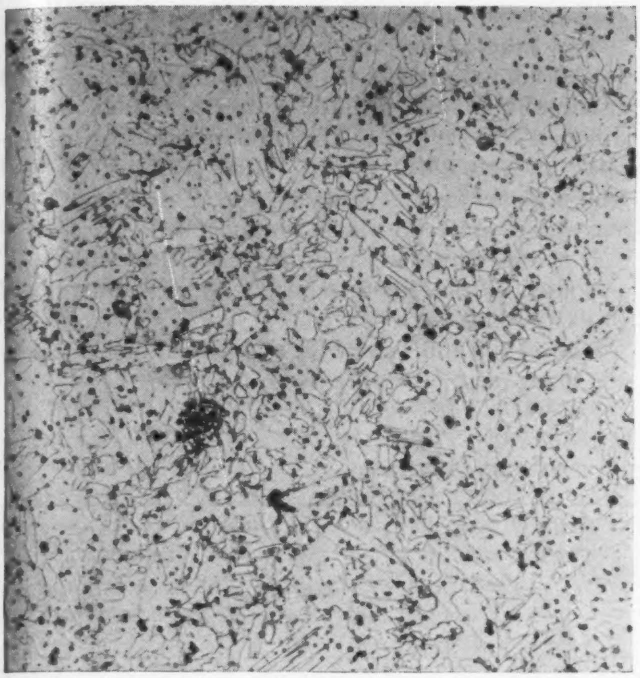


Fig. 1—Vertical sections of two manganese bronze ingots at approximately 2× etched in 10 per cent ammonium chloride solution for two weeks. A, left, shows no evidence of iron segregation, and B, right, shows marked segregation toward the top of the ingot.

Fig. 3A (left)—Photomicrograph at 100× of beta manganese bronze, polarized light, electrolytically polished and etched. Location 1A, Fig. 2. Fig. 3B (right)—Same as Fig. 3A, except magnification is 500×. Areas around the large iron compound segregations are largely denuded of the small iron compound segregations.







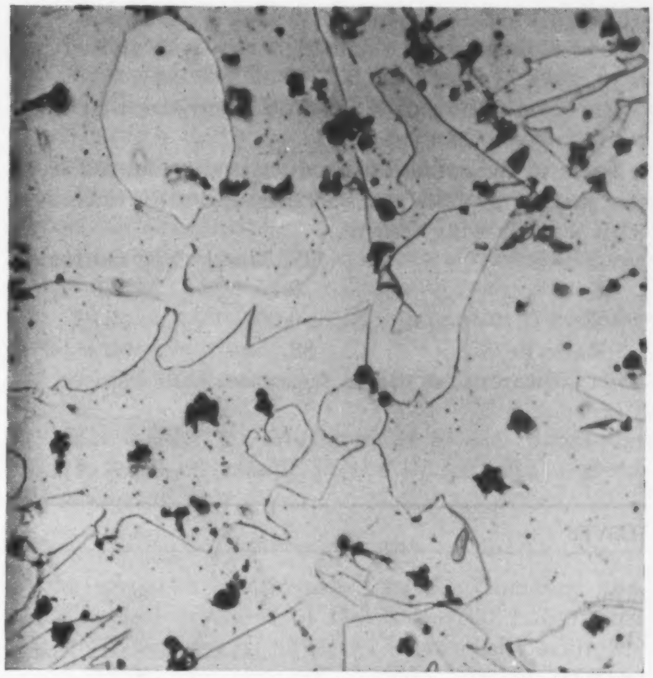
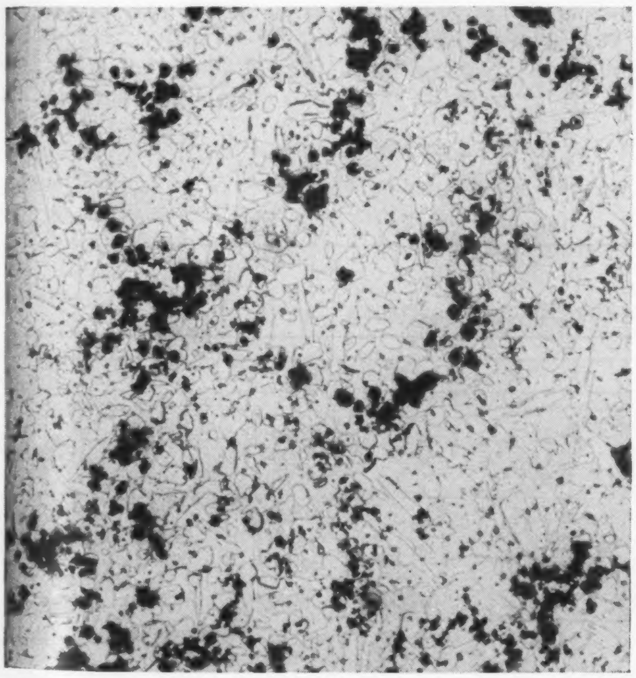


Fig. 4A (left)—Photomicrograph at 100× of an alpha-beta manganese bronze, polarized light, electrolytically polished and etched. Location 2B, Fig. 2, showing satisfactory iron compound distribution. Fig. 4B (right)—Same as Fig. 4A except magnification is 500×.

Fig. 5A (left)—Photomicrograph at 100× of an alpha-beta manganese bronze, polarized light, electrolytically polished and etched. Location 3B, Fig. 2, showing an unsatisfactory iron compound distribution. Fig. 5B (right)—Same as Fig. 5A except magnification is 500×.



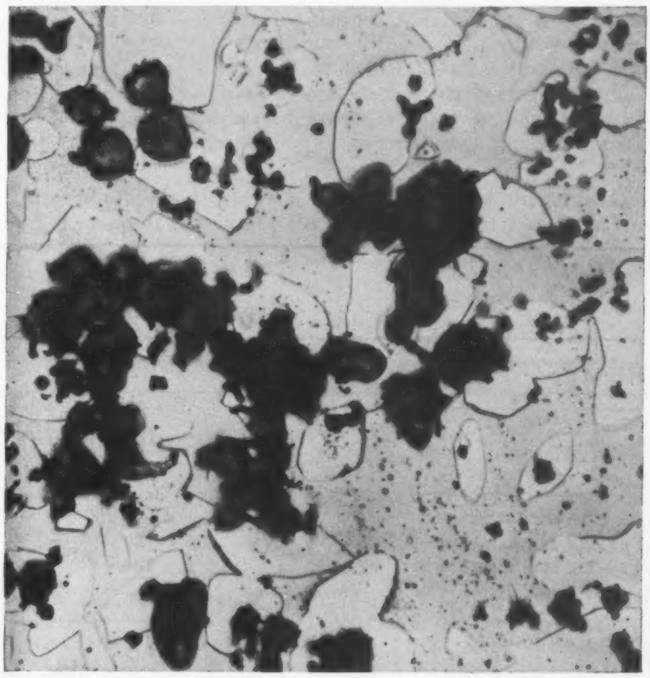


TABLE 1.—AVERAGE ANALYSIS OF SECTION SHOWN IN FIGURE 2.

Sample No.	2A1	2B2	2B3
Cu	55.71	58.83	58.29
Sn	0.30	0.40	0.30
Zn	41.62	38.03	37.55
Zn_e	48.25	44.25	44.81
Pb	0.31	0.23	0.24
Ni	Tr	0.05	0.05
Fe	0.81	1.00	1.96
Al	0.80	0.67	0.70
Mn	0.42	0.78	0.79
Si	0.03	0.01	0.03

Figure 5A, location 3B, of Fig. 2 at 100 magnifications, shows an alpha beta manganese bronze, with a marked segregation of the iron compound. Figure 5B is the same location at 500 magnifications. See Table 1, sample number 2B3, for average analysis of this section.

The symbol Zn_e in the tables is used to denote the zinc equivalents, which were calculated by using Gillet's equivalents.

Spectrographic examination was made of the sections shown in Fig. 1. The location of the spectrographic sparks is indicated in Fig. 2. There was no discernible

difference between sparks 4, 5 and 6 on section "A." Sparks 8 and 9 were much higher in iron and silicon than spark 7 on section "B."

An examination of Fig. 1 would indicate that these results were to be expected.

Some of the corrosion products were removed from the surface of 2B3 and spectrographically examined with the following results:

	2B2 Metal	2B3 Corrosion
Fe	0.70 %	20.0 %
Si	0.008	1.10
Ratio Fe/Si	88.	18.

This indicates that silicon segregates with the iron.

Laboratory Melting Tests

Test heats using commercial manganese bronze ingots of known analysis were melted in a small gas fired crucible laboratory furnace. Silicon was added to the different heats as a calculated amount of silicon bearing alloy, such as PMG (copper 71.06, silicon 22.24, and iron 6.16 per cent). A 50/50 silicon aluminum alloy was also used to add silicon to the melt.

A pyrometer having a chromel alumel thermocouple was used to determine temperatures. Standard keel block test bars were poured.

Tables 2, 3 and 4 show the effect of adding silicon to the manganese bronze heats.

TABLE 2.—PMG ALLOY USED FOR SILICON ADDITIONS.

HEATS	A	B	C	D
		Furnace Charges		
Ingot	100%	99.32%	98.70%	96.60%
PMG	———	0.45	0.90	2.25
Zinc	———	0.23	0.4	1.15
Total charge	100.0%	100.0%	100.0%	100.0%
Furnace temperature	1875°F	1870°F	1885°F	1880°F
Pouring temperature	1840°F	1840°F	1840°F	1820°F
		Physical Properties		
Yield point	32000	30000	29500	26000
Tensile strength	77600	77600	81300	59000
Elongation	11.5%	15.0%	16.0%	5.0%
		Chemical Analysis		
Cu	55.41	55.41	55.26	55.49
Sn	0.10	0.10	0.10	0.10
Zn	42.16	42.21	42.55	42.55
Zn_e	49.36	48.75	48.82	49.97
Pb	Tr	Tr	Tr	Tr
Ni	Tr	Tr	Tr	Tr
Fe	0.85	0.85	0.82	0.70
Al	1.00	0.92	0.89	0.88
Mn	0.48	0.51	0.38	0.22
Si	Tr	Tr	Tr	0.14
Si expected	0.0	0.10	0.20	0.50

TABLE 3.—PMG ALLOY USED FOR SILICON ADDITIONS.

HEATS	E		F		G		H	
			Furnace Charges					
Ingot	100.0%		99.32%		98.64%		96.60%	
PMG	—		0.45		0.90		2.25	
Zinc	—		0.23		0.46		1.15	
Total charge	100.0%		100.0%		100.0%		100.0%	
Furnace temperature	1870°F		1875°F		1880°F		1880°F	
Pouring temperature	1845°F		1840°F		1840°F		1860°F	
	Metal	Sludge	Metal	Sludge	Metal	Sludge	Metal	Sludge
Furnace Products	98.8%	0.0%	97.9%	1.0%	93.7%	5.2%	90.9%	7.85%
			Physical Properties					
Yield Point	25000	—	22000	—	22000	—	25000	—
Tensile Strength	63000	—	63500	—	60700	—	62400	—
Elongation	43.0%	—	41.5%	—	41.5%	—	30.0%	—
			Chemical Analysis					
Cu	58.25%	—	59.36%	57.39%	59.11%	54.29%	59.53%	57.68%
Sn	0.35	—	0.22	Tr	0.34	Tr	0.37	Tr
Zn	38.37	—	38.82	—	38.47	—	38.34	—
Zn_e	45.56	—	45.16	—	44.36	—	45.50	—
Pb	Nil	—	Nil	—	Tr	—	Nil	Tr
Ni	Nil	—	Nil	Tr	Nil	Tr	Nil	Tr
Fe	1.35	—	1.18	4.65	0.95	8.77	0.62	2.59
Al	0.86	—	0.77	1.14	0.68	1.57	0.72	1.73
Mn	0.45	—	0.45	0.68	0.45	0.58	0.28	0.35
Si	Tr	—	Tr	0.33	Tr	1.15	0.14	0.60
Si expected	Nil	—	0.10	—	0.20	—	0.50	—

There was no evidence of a sludge formation in heat A. Heats B, C and D showed increasing sludge formation as silicon was increased. No attempt was made to remove the sludge from the metal in these heats.

The sludge which forms when silicon is added has a tendency to float close to the top of the molten metal, and one would expect the metal in the bottom of the castings and test bars to be more free from the sludge forming constituents than the top of the castings and test bar feeding heads. The samples for chemical analysis and the test bars were taken from the bottom of the castings. This might account for the silicon being lower than expected.

There were no noticeable differences in microstructures. The structures were beta with the iron compound well distributed.

There was no evidence of a sludge formation in heats E and I. However, heats F, G, H, J, K and L showed increasing sludge formation as the silicon additions were increased. The sludge was held back in the crucible by using a skimmer while pouring.

There were no noticeable differences in the microstructures on heats E to L inclusive. The structures were an alpha beta manganese bronze of approximately 50% alpha, with the iron compound well distributed.

It is difficult to account for all the iron, aluminum, manganese and silicon due to the non-homogeneous condition of the sludge and the metal. In general, as the silicon increases there is a tendency for the aluminum, manganese and iron to decrease in the metal, and to increase in the sludge. The sludge consists of a compound high in iron, with considerable entertainment of molten metal.

Summary and Conclusions

Small amounts of impurities in manganese bronze may result in the following conditions:

1. Iron, silicon, aluminum and manganese concentrate in sludge formed during the melting operation.
2. The sludge has a tendency to float close to the top of the molten metal.
3. A silicon content of 0.1 per cent or under will cause enough sludge to form so that it is noticeable on pouring the metal.
4. The amount of sludge formed increases as the silicon content increases.
5. The sludge formation increases as the metal cools from furnace temperature to pouring temperature.
6. There is a tendency for the elongation to decrease as the silicon increases.
7. Sludge in the metal will cause thin castings to misrun.
8. The higher the iron content of the charge the more it will concentrate in the sludge with a given silicon content increases.

Acknowledgment

The generous aid furnished by the Chemical and Metallurgical divisions of the Industrial Laboratory of Mare Island Naval Shipyard is gratefully acknowledged. The assistance of Joseph Bentley, Master Molder, and his staff was of material aid in the prosecution of the work.

Discussion

Chairman: H. M. ST. JOHN, Crane Co., Chicago

Co-Chairman: A. K. HIGGINS, Allis-Chalmers Mfg. Co., Milwaukee

GEO. P. HALLIWELL[1]: The author has brought to our attention a subject so frequently infused into discussions of manganese bronze that it would sometimes seem that they are synonymous. This is unfortunate, because segregations of iron-rich particles can be traced generally to faulty metallurgical practice, either in the original compounding of the alloy or in the foundry.

Iron is added to manganese bronzes to decrease the grain size with a resultant beneficial effect upon mechanical properties. It

[1] Director of Research, H. Kramer & Co., Chicago, Ill.

TABLE 4.—ALUMINUM SILICON ALLOYS USED FOR SILICON ADDITIONS.

HEATS		I		J		K		L
				Furnace Charges				
Ingot		100%		99.8%		99.6%		99.2%
Silicon Aluminum		—		0.2		0.4		0.8
Total Charge		100%		100.0%		100.0%		100.0%
Furnace temperature		1880°F		1880°F		1875°F		1920°F
Pouring temperature		1840°F		1840°F		1835°F		1840°F
				Physical Properties				
Yield point		—		21000		23000		28500
Tensile strength		—		63500		63500		61000
Elongation		—		50.0%		46.5%		21.0%
	Metal	Sludge	Metal	Sludge	Metal	Sludge	Metal	Sludge
Furnace Products	98.9%	0.0%	96.5%	2.1%	95.1%	3.7%	88.6%	9.9%
				Chemical Analysis				
Cu	60.08	—	60.45	54.54	60.55	55.19	60.61	54.23
Sn	Tr	—	0.05	0.05	0.05	0.05	0.05	0.05
Zn	36.94	—	36.76	31.60	36.73	34.56	36.53	32.15
Zn.	43.58	—	45.01	—	45.85	—	46.43	—
Pb	Tr	—	Tr	Tr	Tr	Tr	Tr	Tr
Ni	Tr	—	Tr	Tr	Tr	Tr	Tr	Tr
Fe	1.47	—	0.99	10.89	0.79	6.93	0.68	9.44
Al	0.83	—	1.16	1.29	1.13	1.70	1.33	1.75
Mn	0.68	—	0.59	0.59	0.63	0.67	1.33	1.75
Si	Tr	—	Tr	1.04	0.12	0.90	0.19	1.67
Si expected	Tr	—	0.10	—	0.20	—	0.40	—

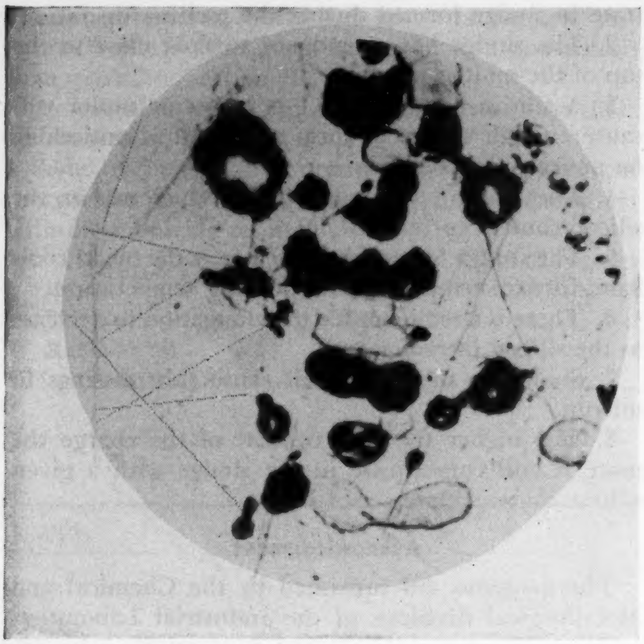


Fig. 6A—Unetched. Mag. 1500X.

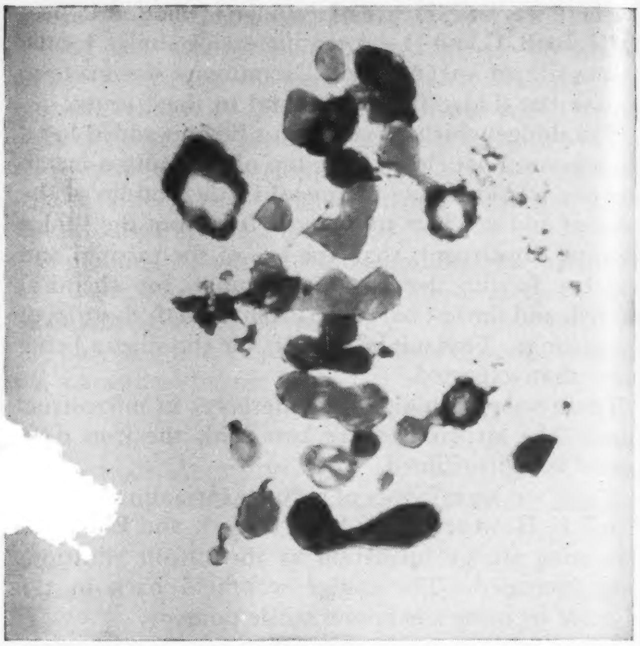


Fig. 6B—Etched. Mag. 1500X.

Fig. 6C—Unetched. Mag. 100X.

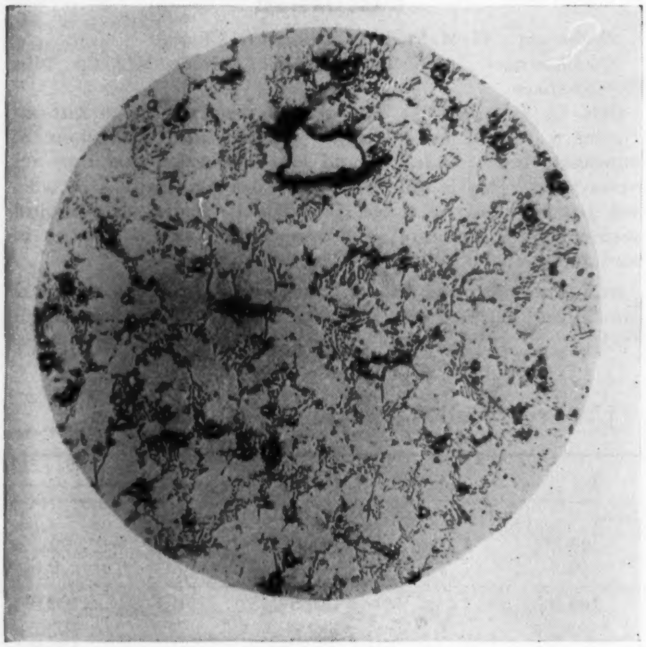
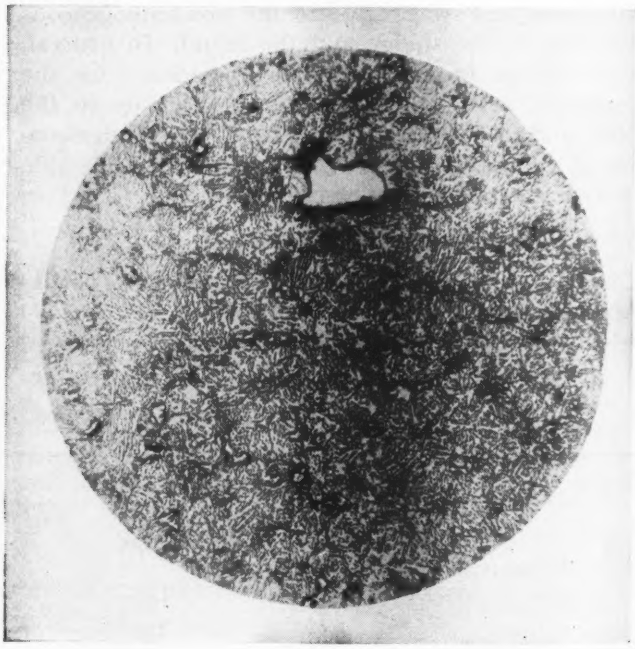


Fig. 6D—Nital etch. Mag. 100X.



may be added as metal or as a suitable hardener. It is claimed by some investigators that better mechanical properties are obtained by the use of hardeners, although this has not been the writer's experience. When properly alloyed, iron is soluble in the liquid state as discreet particles of the iron-rich compound, such as shown by Mr. Dalbey in Fig. 3 A.

It is unfortunate that the author used the electrolytic etch, as the conventional aluminum oxide and broad cloth technique produce better results. It is difficult to distinguish, in Fig. 3 B, between lead, holes, iron-compound and the effects of tarnish. The area around the large particles which appears to be denuded of iron may be real, but the writer has seen such a condition removed by a light mechanical polish on broad cloth.

If the iron has not been properly alloyed it will occur as segregations of hard metallic particles. The presence of silicon in some of these particles indicates that part of the iron and manganese has been oxidized and combined with silica. The source of the silicon may be the sand on returned gates, sprues, etc., or from the crucible or furnace lining. An area consisting of the normal iron-rich constituent and iron-rich silica particles is seen in Fig. 6 A and 6 B at 1500 diam. In the unetched condition (Fig. 6 A) the normal iron-rich constituent is seen as a light colored phase outlined in a back ground of about the same tone. The slag particles show as dark gray. Etched lightly with a weak solution of acidulated ferric chloride, the normal iron-rich particles become black and the slag particles remain essentially the same. In this manner the two constituents are readily distinguished. Such slag, however, should rise to the top of the metal and be skimmed off before stirring or pouring.

A second type of iron-rich material results when the iron or hardener is not fully dissolved. This frequently happens when attempts are made, after zinc and aluminum are added, to increase the iron content. A piece of copper iron hardener is seen in Figs. 6 C-E. The unetched condition is shown in Fig. 6 C and

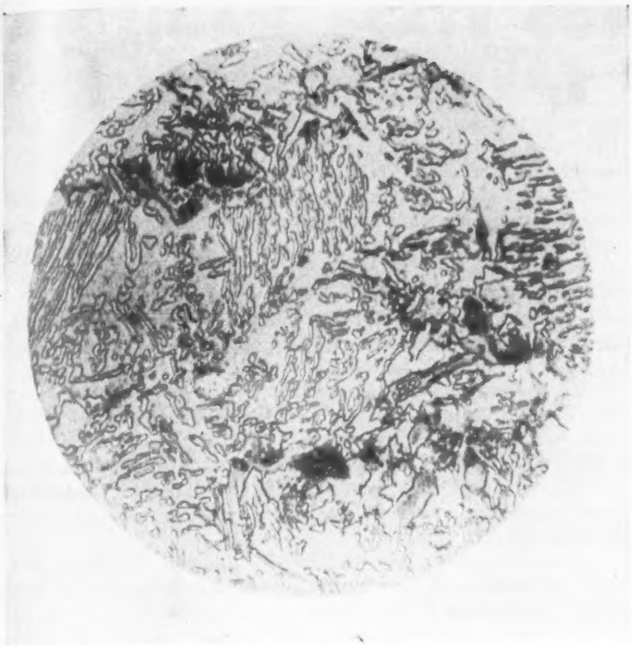


Fig. 6E—Etched. Mag. 500×.

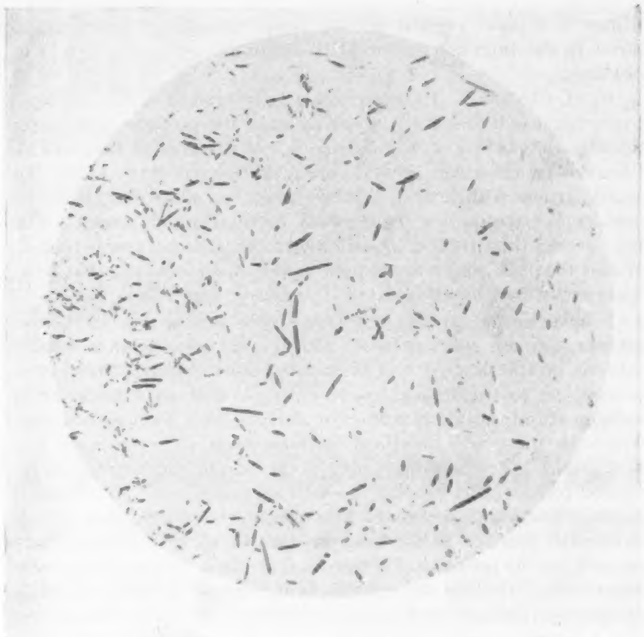


Fig. 6F—Unetched. Mag. 100×.

etched in Fig. 6 D at 100× and Fig. 6 E at 500×. High iron content is confirmed by its reaction to the etchant, 4 per cent nitric acid in alcohol (Nital). The internal structure appears to be the eutectoid (alpha plus eta) shown in the copper iron diagram (1).

Test bars containing such hard particles are difficult to machine and will usually show low mechanical properties. If the iron particles are of the order of a few thousandths of an inch in diameter, the fractured test bar will show small pin point mounds on one section of the bar and corresponding sharp pointed depressions on the opposite section. Such a fracture is accompanied by decreased properties, although they may not necessarily be below specifications limits. If silicon is present as an alloying element it is found precipitated as small needles or plates uniformly distributed throughout the alloy. Fig. 6 F shows its appearance in a low iron alloy and Fig. 6 G in a high iron alloy.

Several years ago, in a discussion of a paper by Dr. Gillett on "The Role of Silicon in Non-Ferrous Castings," [2] the writer presented data on the mechanical properties of manganese bronzes containing from 0 to 0.6 per cent silicon. For every 0.1 per cent silicon present the mechanical properties of a manganese bronze containing 58 per cent copper and one per cent each of aluminum and iron were affected as follows:

Tensile Strength	+1600 psi.
5% Yield Strength	+4000 psi.
% Elongation	—4.5
Brinell Hardness	+8

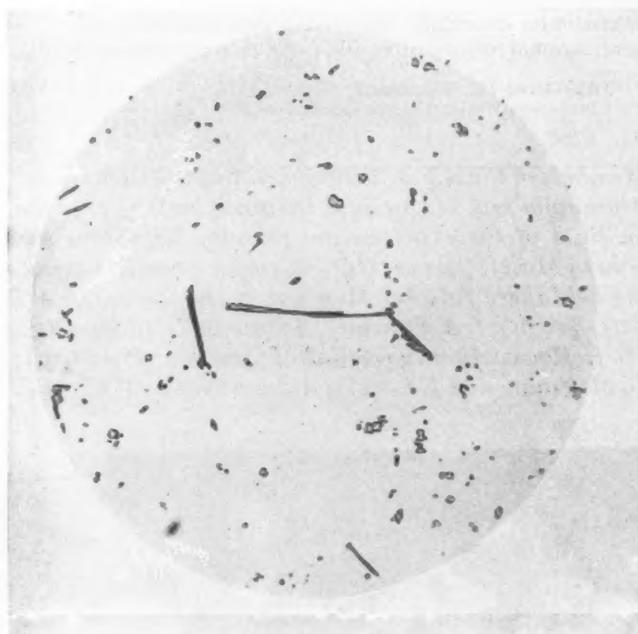
The rapid increase of the yield strength is of particular interest.

When silicon is desired in a manganese bronze containing normal amounts of iron, there will always be a loss of both silicon and iron, such as was found by the authors of the present paper. However, in the above mentioned alloys [2] no difficulty was experienced from the formation of a slag. That it was formed is evident from the loss of iron in the original alloy and the loss of about half the silicon added.

It is not clear from Mr. Dalbey's paper whether each heat of the same general copper content was made from the same batch of metal. If so, the progressive decrease in iron, heats E to H, would be expected. It is rather surprising that no silicon was retained in heats F and G. At least a few hundredths would be expected, unless the PMG hardener was not thoroughly immersed in the liquid.

In general, the properties given in the paper are lower than those the writer is accustomed to associate with this alloy and composition. This is especially true of the alloys with high silicon contents, heats H, K and L. This may be due in part to the use of a different test bar. We use the ⅝ in. web-webbert molded and poured flat.[3] The use of the term "yield point" is very misleading. It is generally accepted that a yield point does not exist in copper-brass alloys. The Navy specifies yield strength at 0.2 per cent offset, while A.S.T.M. recommends the yield strength at "0.5 per cent elongation while under load," as an alternative. Both these yield strengths are commonly used, but they should be and are generally identified, as they vary with respect to each other in the higher strength bronzes. Whereas the offset yield is lower in the low strength bronzes it is considerably higher than the 0.5 per cent yield strength in the 100,000-pound manganese bronze.

Fig. 6G—Unetched. Mag. 100×.



In conclusion, the writer should like to emphasize that segregations of hard spots in manganese bronze are not endemic to that alloy, but are the results of faulty metallurgical practice either when the alloy is first made or later melted. If any of the iron and manganese becomes oxidized, it is a metallurgical axiom that they combine with the nearest silica available to form a slag. Free

silicon is seldom present in the usual manganese bronzes and never in the high strength type, if optimum properties are to be obtained.

G. H. CLAMER[1]: I was particularly interested in Mr. Dalbey's paper because it may have a bearing upon the problem now under investigation before Subcommittee B-1 of Committee B-5, ASTM. I have been chairman of that subcommittee for many years. To a task group within that subcommittee has been delegated the problem of explaining hard spots in manganese bronze. The task group submitted a questionnaire to persons competent to discuss that subject. The majority were of the opinion that hard spots are caused by undissolved iron containing carbon.

I have never investigated manganese bronze for its silicon content, nor the effect thereof. There is no restriction on silicon content in the present ASTM specifications covering manganese bronze. As to silicon pickup, recently we had an experience in melting aluminum in an induction furnace with a siliceous lining. Although there was no silicon pickup when the aluminum was held around its melting point, when the temperature was increased considerably beyond the melting point there was a silicon pickup of about 2 per cent. Manganese bronze contains aluminum. The reaction of the same on the silicate of the lining may account for the presence of silicon in that alloy. Manganese bronze when molten reaches the reaction temperature. It is worth while to investigate silicon pickup in manganese bronze for that reason.

I have never previously heard of the silica sludge described by Mr. Dalbey as being present in manganese bronze.

J. F. EDNIE[2]: It might be helpful in this discussion to report some of our experiences, some years ago, in regard to hard spots in manganese bronze. We found that a hard spot was always associated with a segregation of iron; that is, the hard spot was always iron-rich. There was one puzzling feature, namely, the presence of such iron-rich segregations did not necessarily lead to machining difficulties. But always when machining difficulties were encountered, the iron-rich particles were responsible. We had occasion to isolate some of these hard spots which were causing machining difficulties and we found that the Brinell hardness of these spots varied considerably, but went as high as 300 or more.

In all cases the carbon content would range from 0.7 to 1.4 per cent, the manganese up to 10 per cent and the silicon up to 1 per cent. I think this information is a very important addition to what Mr. Dalbey has been bringing to our attention.

In conclusion, I think the method of manufacture of manganese bronze is an important consideration to remedy this trouble. It is possible to make the alloy containing many hard spots. Our company, after considerable research on this subject went exclusively to the use of electric furnaces for the manufacture of manganese bronze. Since that time this problem of segregation has been completely eliminated and we have never encountered a case of difficult machining.

MR. DALBEY *(author's closure):* The author wishes to thank Messrs. Halliwell, Clamer and Ednie for their constructive discussions.

Replying to Mr. Halliwell's comment as to whether heats E to H were made from the same batch of metal. They were made from a lot of commercial ingot all of which had the same heat number stamped on each ingot.

It is believed that the PMG was in solution. It will be noted that the amount of iron in the sludge is considerably in excess of the iron added in the PMG.

The figures for yield point were arrived at by the divider method, and are approximate yield strengths.

[1] Ajax Metal Co., Philadelphia.
[2] Duquesne Smelting Corporation, Pittsburgh.

References

1. *Metals Handbook,* 1939 edition, p. 377, ASM, Cleveland, Ohio.
2. H. W. Gillett, "The Role of Silicon in Non-Ferrous Castings," TRANSACTIONS, American Foundrymen's Association, vol. 46, p. 413 (1938).
3. G. H. Glamer, "Test Bars of 85-5-5-5 Their Design and Some Factors Affecting Their Properties," TRANSACTIONS, American Foundrymen's Association, vol. 54, p. 1 (1946).

Members of the A.F.A. Centrifugal Casting Committee, Aluminum and Magnesium Division, looking over the facilities of the experimental foundry, Canadian Bureau of Mines, Ottawa, Ont., during a committee meeting held there July 31. Members of the committee are (left to right): J. A. Fulwider, Allison-Bedford Foundry; H. J. Rowe, Aluminum Co. of America, Pittsburgh; G. M. Young and J. Loucks, Aluminum Co. of Canada, Long Branch, Ont.; Walter Bonsack, National Smelting Co., Cleveland, Ohio; J. W. Meier, Canadian Bureau of Mines, Ottawa, Ont.; Committee Chairman David Basch, Almin. Ltd., Schenectady, N.Y., Sam Tour, Sam Tour & Co., Inc., New York; H. R. Youngkrantz, Apex Smelting Co., Chicago; M. E. Brooks, Dow Chemical Co., Bay City, Mich., and R. J. Traill, chief, metallurgy division, Canadian Bureau of Mines.

MICHIGAN STATE CONFERENCE PROGRAM OF GREAT INTEREST

FRIDAY AND Saturday, October 31 and November 1, have been set aside by the four sponsoring A.F.A. chapters and Michigan State College as the days for staging their annual Michigan State College Foundry Conference. The two-day meeting will convene at the Michigan State College, East Lansing, Mich. The four A.F.A. chapters cooperating in putting on the conference are Saginaw Valley, Western Michigan, Detroit and Central Michigan.

The tentative program and schedule of events have been arranged and are shown in the accompanying box.

Speakers have been obtained for all the sessions and the program committee is enthusiastic over the prospects of one of the largest groups ever to attend a Michigan State College Foundry Conference. Meetings will be held in R. E. Olds Hall of Engineering.

Hotel reservations should be made immediately and direct with the Olds, Porter or Roosevelt hotels in Lansing, Mich.

Chairman of the Michigan State College Foundry Conference is C. C. Sigerfoos, Michigan State College. He is ably assisted by the following men who are aiding in making the program and conference a success: F. S. Brewster, H. W. Dietert Co., Detroit; M. V. Chamberlin, Dow Chemical Co., Bay City; Charles Locke, West Michigan Steel Foundry Co., Muskegon; Harold Myers, Sealed Power Corp., Muskegon Heights; R. G. McElwee, Vanadium Corp., Detroit; E. E. Woodliff, Foundry Sand Service Engineering Co., Detroit; Fitz Coghlin, Jr., Albion Malleable Iron Co., Albion; and L. G. Miller, H. L. Womochel and N. C. McClure, all of Michigan State College.

FOUNDRY-BUYER COOPERATION URGED AS AID TO PRODUCTION

CONSUMERS of gray and malleable iron castings play an important part in the performance record of the foundries supplying them, D. J. Reese, International Nickel Co., New York, told the steel group of the National Association of Purchasing Agents at a recent meeting in the Waldorf-Astoria.

Speaking on "Gray Iron and Malleable Castings: How Much? . . . When? . . . For How Much?", Mr. Reese told the buyers: "The two most important elements in the foundry process of manufacture are 'proper scheduling of parts for production' and 'production' itself.

"As the foundry industry acts as your sub-contractor, its scheduling is actually your scheduling. You could easily overlook the importance of proper scheduling if you did not realize that these two indus-

(*Continued on page 86*)

Michigan State College Foundry Conference

Michigan State College, East Lansing
October 31 - November 1

Friday, October 31

8:30 am—Registration

9:30 am—Opening Session

CHAIRMAN, A. H. Allen, Penton Publishing Co., Detroit, *Address of Welcome*

10:00 am—*Foundry Training Programs,* A. W. Gregg, Whiting Corp., Harvey, Ill.

11:00 am—*Work Measurement and Wage Incentive,* C. H. Pesterfield and J. M. Apple, Michigan State College.

12:30 pm—Luncheon

CHAIRMAN, H. B. Dirks, Dean of Engineering, Michigan State College.
The Veteran Student Looks at Jobs and Employers, C. J. Fruend, Dean of Engineering, University of Detroit, Detroit.

2:30 pm—Steel Round Table

CHAIRMAN, Charles Locke, West Michigan Steel Foundry Co., Muskegon, Mich.
DISCUSSION LEADER, E. C. Troy, Dodge Steel Co., Philadelphia.
Heading and Feeding of Steel Castings.

2:30 pm—Gray Iron and Malleable Iron Round Table

CHAIRMAN, W. B. McFerrin, Electro Metallurgical Co., Detroit.
DISCUSSION LEADER, R. G. McElwee, Vanadium Corp., Detroit.
Operating the Cupola Under Material Difficulties.

3:30 pm—Technical Session

CHAIRMAN, A. J. Edgar, Benton Harbor Malleable Industries, Benton Harbor, Mich.
Mechanization in the Foundry, W. R. Jennings, John Deere Tractor Works, Waterloo, Iowa.
Testing the Scrubbing Tendencies of Molding Sands, Wayne Edwards and Lionel Washington, students, and C. C. Sigerfoos, Michigan State College.

6:00 pm—Conference Dinner.

Saturday, November 1

9:00 pm—Technical Session

CHAIRMAN, C. F. Joseph, Central Foundry Div., General Motors Corp., Saginaw, Mich.
Westonite in Foundry Sands, T. W. Curry, Lynchburg Foundry Co., Lynchburg, Va.
Non-Ferrous Casting Defects, H. M. St. John, Crane Co., Chicago.
The Selection and Use of Core Oils and Binders, E. E. Woodliff, Foundry Sand Service Engineering Co., Detroit.

2:30 pm—Football game

Michigan State College vs. Marquette University.

CAST STEELS

Recent Developments Concerning Properties

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Technical and Research Director
Steel Founders' Society of America
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This is the second and concluding installment of the paper, originally presented before the Semi-Annual Meeting of ASME in Chicago, June 16-19, 1947. Part I appeared in the September issue.

THE PRINCIPAL REASON for studying 0.30 per cent carbon steel having a wide variety of alloy contents was to demonstrate the extensive range of hardenability values obtainable. Higher alloy contents provide higher hardenability values, which means that thicker sections can be hardened throughout or that higher hardness and strength can be imparted to sections which cannot be hardened throughout.

Additions of various percentages of alloying elements do enhance the strength of steels in the quenched and tempered condition, but their greatest value lies in the fact that they increase the depths to which such steels can be hardened. These points can be checked by comparing the mechanical properties of low-alloy cast steels, as set forth in the preceding section, with the hardenability values of the same steels as shown in the charts.

The effect of carbon content on the hardenability of a single alloy steel composition is shown in Fig. 17, which sets forth values for a nickel-chromium-molybdenum cast steel (8600 class) produced with various carbon contents.

The degree of hardenability required for specific steel castings depends largely upon the type of stresses to which the castings will be subjected in service. These requirements may vary from a deep-hardening steel to a shallow-hardening steel. It will be noted from the illustrations in this report that any degree of hardenability can be attained by selecting the proper cast steel.

Low Temperature Properties

Steel castings are being used as parts of industrial units which, in service, operate all the way from atmospheric temperatures to as low as –300 F. Applications of steel castings in the low temperature processing fields will be extended manyfold when engineers acquire a better understanding of the properties of cast steels at low temperatures. The comprehensive test results on the low-temperature properties of cast steels presented here should give engineers and purchasers a handy reference to aid them in the selection of materials for low-temperature applications.

Static Tests

Results of the study of cast steels, as well as similar studies of wrought steels, show that there is little change in the strength and hardness properties of steels as the temperature of testing is lowered. Steels become harder and stronger as the temperature drops. This increase in strength is accompanied by a small decrease in ductility; however, the decrease is less than that resulting from variations of composition or heat treatment measured at room temperatures.

The block diagram of Fig. 23 illustrates increases in tensile strengths which may be expected when cast steels are tested at room and low temperatures. The values illustrated in Fig. 23 are typical of results recorded for other grades of cast steel. The elongation values will drop approximately 2 per cent and the Rockwell C hardness will increase about 4 points when testing temperature is lowered from 75 to –150 F.

It is evident that the change in static properties is very slight at service temperatures down to –150 F, and that engineers need have little or no concern regarding changes in static properties of cast steels when used in low-temperature services.

Notched-Bar Impact Tests

The failure of static tests to serve as accurate criteria of the fittness of metals and alloys for low-temperature service applications prompted users to devise a test which would differentiate more clearly between ductile and brittle fracture conditions. It was observed that the single-blow notched-bar test, known as the "impact test," may disclose a brittle fracture in a steel tested at low temperatures even though tension-impact tests on unnotched bars and static tests indicate a steel having satisfactory ductility.

Accordingly, the notched-bar impact test has become quite widely accepted as a means of determining the brittle or ductile behavior of steels at temperatures below 70 F. The acceptability of steels for low-temperature application is based almost entirely on their reaction to notched-bar impact tests at service temperatures to which they will be subjected.

The two types of test specimens most frequently used for low-temperature impact testing are the keyhole Charpy test, and the V-notch Charpy bar. The test specimens have the same size cross section (10x10 mm). The keyhole notched-bar has a round hole at the base of the notch. The V-notch is a much sharper notch, and subjects the specimen to a severe concentration.

The V-notch is cut to a depth of 2 mm, leaving a breaking section of 10x8 mm instead of the 10x5 mm breaking section of the keyhole notch type.

At temperatures approaching normal atmospheric conditions, the V-notch bar is more sensitive to small changes than the keyhole notch bar. Values recorded for the V-notch bar may be more than twice those recorded for the keyhole notch bar on the same steel at temperatures in the neighborhood of 70 F. However, at low temperatures, the V-notch bar values may be equal to, or even less than, the keyhole notch-bar values for the same steel. This greater spread in V-notch bar values magnifies the transition range from ductile to brittle fracture conditions and provides more exact differentiation.

Both the keyhole notch bar and the V-notch bar were used in reporting test values for the study of cast steels.

Certain carbon and low-alloy steels show a rather pronounced transition range. The change from a tough, ductile fracture to a brittle fracture occurs over a range of temperatures, and if testing is carried on in this temperature range, the resulting fractures may be mixed, with brittle patches appearing along with tough, ductile areas. Since the fracture characteristics do not change abruptly from a ductile to a brittle fracture at any specific low temperature, there are bound to be certain variations in the individual test bar results in the transition range. In some cases, these variations may be quite wide.

The position of the transition range cannot be predicted from mechanical testing other than notched-bar impact tests, nor from the composition, microstructure, or heat treatment of the steel. One might conclude that steel heats are individualistic from the standpoint of notched-bar impact values at low temperatures. This is not true, however, if the steels are produced as dead-killed, fine-grained steels without deleterious types of non-metallic inclusions. Such steels, if they have comparable hardenabilities, may be presumed to have somewhat similar low-temperature impact properties.

Carbon Cast Steels

Information as to the normally expected impact properties of carbon cast steels is included in this report, not because carbon steel castings are commonly used in low-temperature applications, but because they provide a set of reference points by which to gage the effect of the carbon content of steels on their low-temperature notch-bar impact properties. A knowledge of the effect of carbon content on notched-bar impact properties simplifies the study of a number of alloy steels, since impact values for such steels, all having a single selected carbon content, can be compared.

The analyses of the carbon cast steels for which impact values are given are set forth in Table 7.

Figure 24 shows the impact values that were obtained after subjecting the three carbon steels to two different heat-treatments. The curves show that the carbon content of a steel affects the notched-bar values at both normal and subnormal temperatures. In general, the lower the carbon content of the steel, the higher are the impact properties. This principle of low carbon-high impact properties also applies to alloy steels.

A study of Fig. 24 reveals the fact that the carbon cast

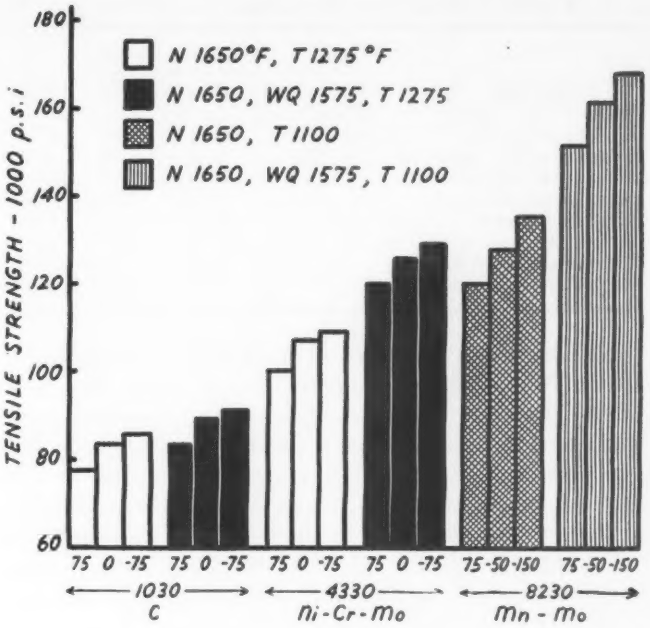
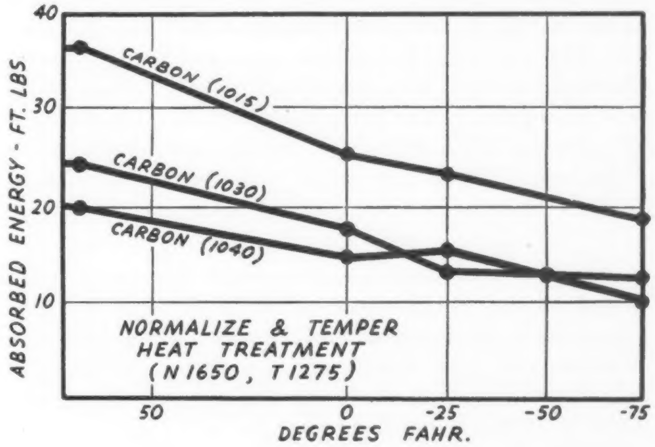


Fig. 23—The static tensile strength properties of cast steels at normal and low temperatures.

Fig. 24—Effect of temperature on impact strength-Charpy keyhole notch properties of carbon steels. N = normalized, WQ = water quenched, T = tempered.



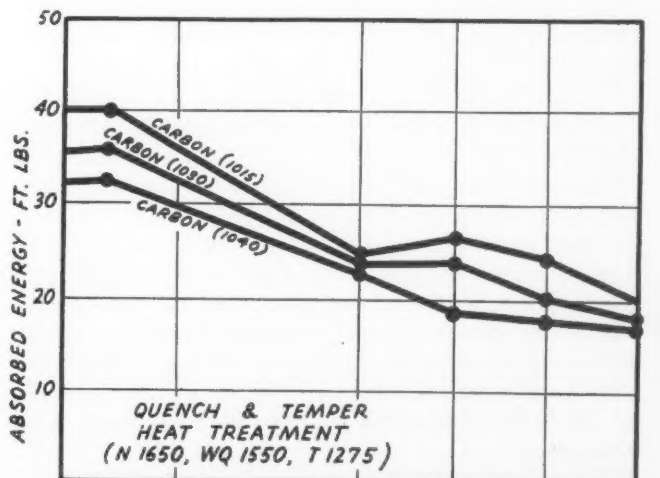


TABLE 7—ANALYSES OF CARBON CAST STEELS

Element	Steels 1015	1030	1040
Carbon, per cent	0.17	0.30	0.38
Manganese, per cent	0.74	0.60	0.72
Silicon, per cent	0.49	0.36	0.41
Phosphorus, per cent	0.032	0.035	0.030
Sulphur, per cent	0.033	0.034	0.037
Nickel, per cent	0.09	0.07	0.09
Chromium, per cent	0.04	Trace	0.03
Molybdenum, per cent	0.02	0.02	0.03

TABLE 8—ANALYSES OF ALLOY CAST STEELS

Element	Steels X4130	2330	3130	4630	4330	8230
Carbon, per cent	0.30	0.26	0.26	0.30	0.26	0.33
Manganese, per cent	0.71	0.62	0.73	0.68	0.59	1.38
Silicon, per cent	0.29	0.31	0.43	0.39	0.44	0.58
Phosphorus, per cent	0.022	0.029	0.030	0.025	0.032	0.023
Sulphur, per cent	0.019	0.026	0.042	0.042	0.023	0.031
Nickel, per cent	0.03	3.36	1.10	1.66	1.82	—
Chromium, per cent	0.82	0.10	0.69	0.20	0.62	—
Molybdenum, per cent	0.22	—	—	0.28	0.30	0.28

steels lost about one-third of their impact strength between 70 and zero F; however, the fractures were not of the characteristic brittle type. The impact strength decreased fairly uniformly from zero to −75 F with still no pronounced transition range. Normally, if the Charpy impact value is greater than 10 ft-lb, there is little brittle constituent in the fracture. Carbon steels were not tested below −75 F since carbon steel castings are not normally used for such low temperature service.

The type of heat treatment given to carbon steels has a marked effect on their impact values. At all testing temperatures down to −75 F, the annealing treatment produces the lowest values, whereas a water quench and high-temperature temper gives the highest values. However, the effect of different heat treatments diminishes at the lower testing temperature.

It should be stressed that while fine-grained, fully hardenable carbon steels in the quenched and tempered state exhibit fairly high impact values at low temperatures, casting sections must be rather thin in order that the characteristic quenched structure be produced throughout the cross section. Since the addition of alloys to steel permits greater opportunity for the casting section to be completely hardened throughout by liquid quenching, it is usual to add alloys to steel in order to secure improved notched-bar impact values.

Alloy Cast Steels

A number of representative alloy cast steels were tested at low temperatures to indicate their possible application and comparative merits for low-temperature service. The analyses of the alloy cast steels for which notch-bar impact properties at low temperatures were determined are given in Table 8.

Three alloy cast steels were tested by using keyhole notch and V-notch specimens after various heat treatments had been given the steels. The results of the tests are presented in graphic form in Figs. 25, 26 and 27.

In Fig. 25, it will be noted that by using X4130 steel it was possible to triple the Charpy keyhole notch value at atmospheric temperature by the employment of a tempering treatment following the normalizing treatment. When a quench and temper treatment was used, the impact value was over four times that obtained when the steel was given only a normalizing treatment. The keyhole notch impact values for the steel in the normalized and tempered condition decreased almost in direct proportion to the drop in testing temperature, with a value at −150 F almost equal to that recorded for the same steel at 70 F with only a normalize heat treatment.

If a water quench and temper heat treatment is applied, the keyhole impact values remain high until the testing temperature has dropped below −50 F. An impact value of 17 ft-lb at −185 F with the broken bars all showing ductile fractures is excellent.

The various types of heat treatment applied to X4130 cast steel has a pronounced effect upon the V-notch impact values, especially at temperatures above −100 F. Values greater than 70 ft-lb at 70 F and more than 60 ft-lb at −50 F are certainly impressive. The room temperature impact values obtained from the quenched and tempered steel were nearly double those of the normalized and tempered steel. The X4130 normalized steel had low impact values at all testing temperatures.

Figure 26 shows that changes in heat treatment are not so influential in the case of a nickel (2330) steel at various low temperatures. Impact values of the normalized steel are good, in fact, much superior to those of X4130 for the same heat treatment. The keyhole notch test indicates that there is little to be gained by using the quench and temper heat treatment rather than the normalize and temper treatment; however, the V-notch bar shows that there is considerable advantage to be gained by using a quenched and tempered steel for low temperature applications.

The V-notch tests indicate that while there is no great difference in values at 70 F, regardless of heat treatment, at testing temperatures of 0 to −100 F, there is considerable difference between the quench-and-temper curve and the two curves for the normalized steel.

The Ni-Cr steel 3130 of Fig. 27 exhibits little difference between the keyhole notch impact values and two of the three V-notch values at 70 F. There is a wider spread between the quenched and tempered values and those from the two normalized treatments than was found in the case of 2330 steel. There is a noticeable break in the quenched and tempered curves at −50 F; nevertheless at −185 F the fracture surfaces had a predominately ductile appearance.

An interesting observation regarding Figs. 25, 26 and 27 is the fact that higher values are obtainable when using the V-notch specimen at 70 F, for normalized and tempered, and quenched and tempered steels. The V-notch specimen values remain high compared to keyhole notch specimen values for water-quenched and tempered steels to testing temperatures as low as −50 F.

At temperatures of −100 degrees F and below, there is little difference between the values, regardless of the type of notch used. If anything, the keyhole notch specimen values were higher than those obtained from the V-notch specimens. There appeared to be little difference whether the V-notch or the keyhole specimen was used, in the case of steel subjected to a simple normalizing heat treatment.

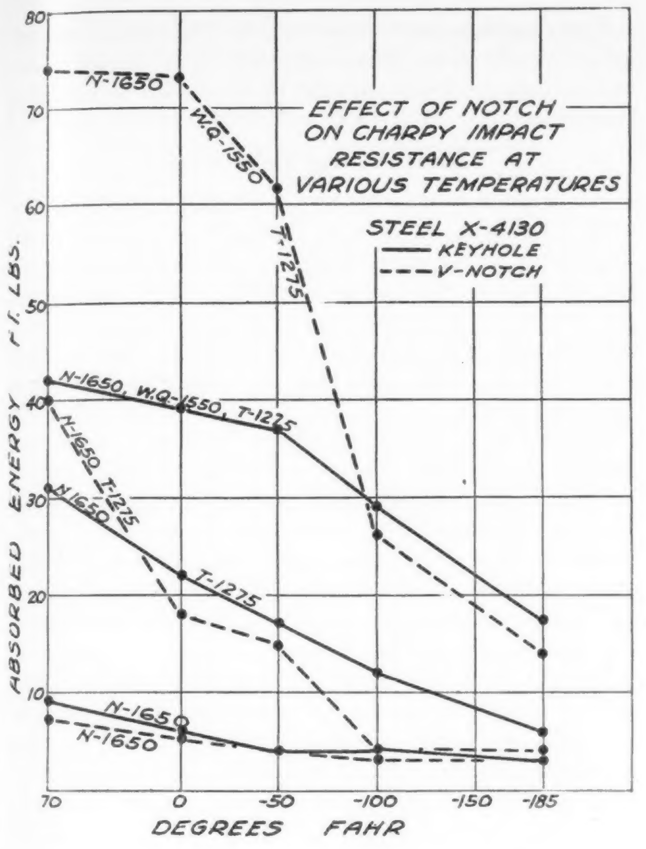


Fig. 25—Effect of notch on Charpy impact resistance at various temperatures for Cr-Mo cast steel X4130.

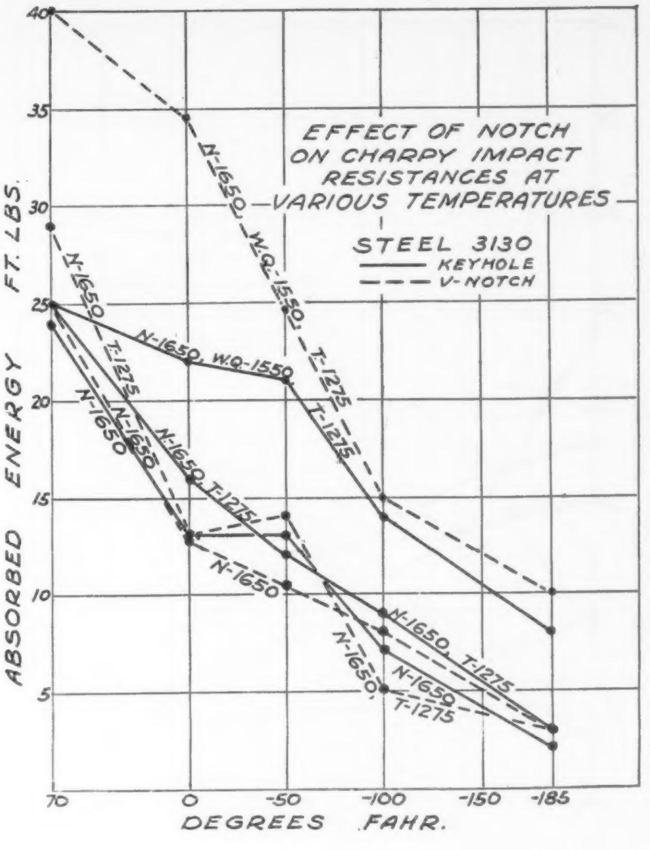


Fig. 27—Effect of notch on Charpy impact resistance at various temperatures for Ni-Cr cast steel 3130.

Fig. 26—Effect of notch on Charpy impact resistance at various temperatures for nickel cast steel 2330.

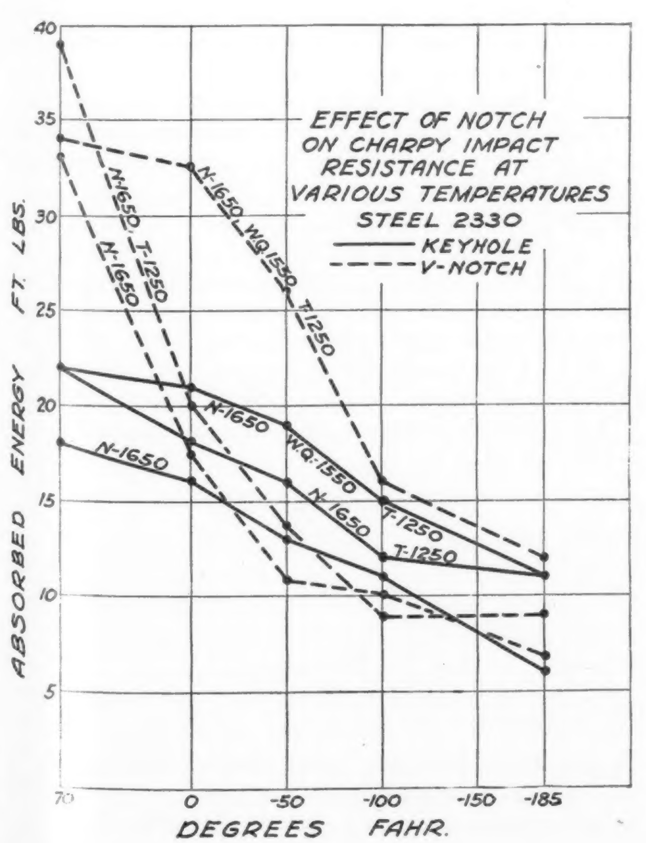
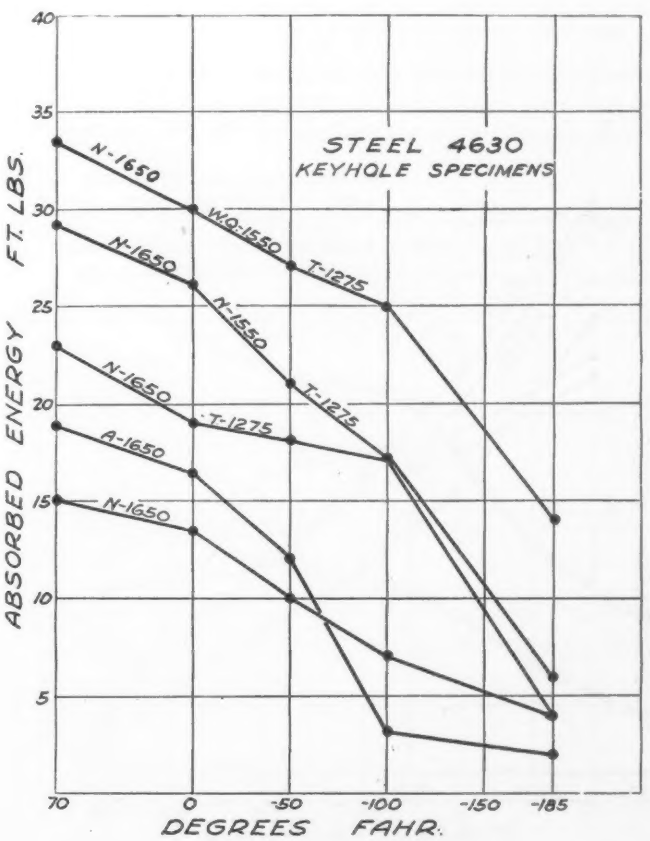


Fig. 28—Curves showing Charpy keyhole impact values for Ni-Mo cast steel 4630.



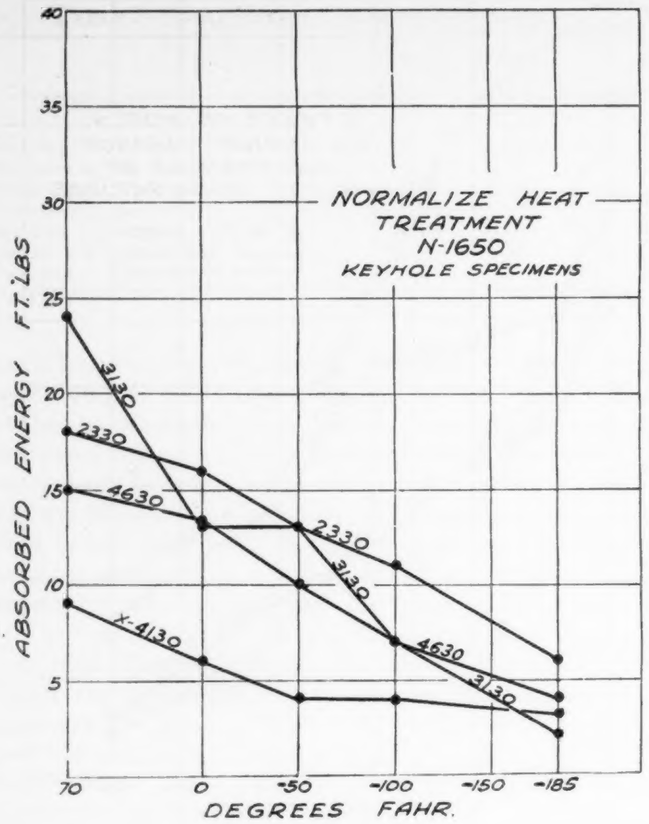
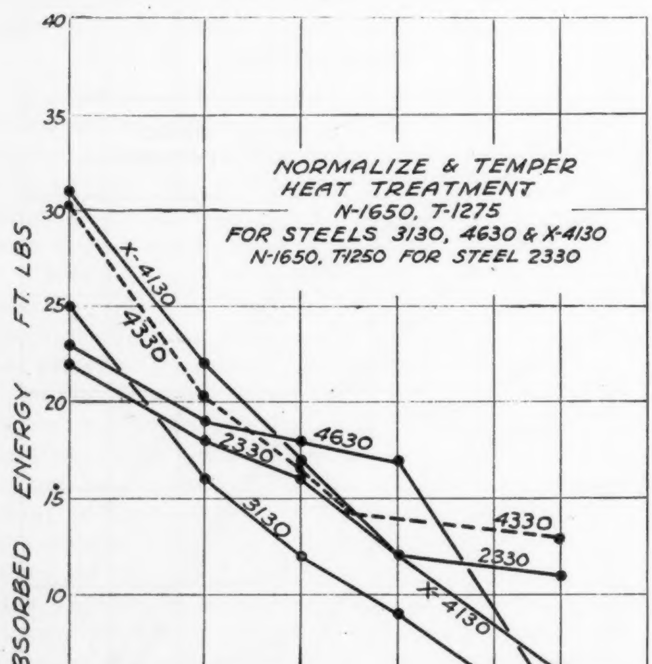


Fig. 29—Comparison of Charpy keyhole impact resistance values at various temperatures for alloy cast steels given a normalize heat treatment.

Fig. 30—Comparison of Charpy keyhole impact resistance values at various temperatures for alloy cast steels given a normalize and temper heat treatment.



The comparative V-notch and keyhole notch impact values for the three alloy steels (X4130, 2330, and 3130) are indicative of what would be found for other alloy cast steels.

Effect of Heat Treatments

The type of heat treatment is usually very important in determining the values obtained in notched-bar impact testing. Figure 28 graphically illustrates the effect of heat treatment on a Ni-Mo (4630) cast steel. An annealing treatment gives higher values than a normalizing heat treatment for temperatures of from 70 to –50 F. The curve for the annealed steel then falls off rapidly.

At 70 F a double normalizing treatment produced double the keyhole Charpy value of specimens given only a single normalize heat treatment. However, as the testing temperature was dropped, the values converged until at –185 F they were only a few foot-pounds apart. The values obtained from testing the quenched and tempered steel were highest, regardless of temperatures employed in the tests.

Figures 25 to 28 definitely establish the fact that neither an annealing nor a normalizing heat treatment develops the best low-temperature impact properties at temperatures of –100 F and below. If a normalizing heat treatment is advisable, the best impact values at low temperatures can be obtained from the nickel steel (2330), as is clearly shown in Fig. 29.

The effect of the same heat treatment on various cast steels is shown graphically in Figs. 29, 30 and 31. These curves largely speak for themselves. The steel casting industry has long known that a nickel cast steel with only a normalizing heat treatment gave good results in low-temperature service. However, service requirements in the past did not often go to temperatures below –50 F. In the case of steels for service below –50 F, it is evident that a normalize and temper, or a quench and temper heat treatment should be used.

It will be noted from Fig. 30 that the results for five alloy cast steels which received a normalize and temper heat treatment are very close together in keyhole notch values over the entire testing range, the values for no one steel being outstanding.

Figure 31 shows that X4130 cast steel is superior to the others for low temperature service when a quench and tempering treatment is used. This is especially true for service requirements at temperatures down to –100 F. Even though the alloy steels do show a change in direction of the curves at –50 F, they nevertheless exhibit ductile fractures and high impact values at –100 and –185 F.

High Temperature Required

The tempering temperature that should be employed, regardless of the heat treatment specified, to obtain the best notched-bar impact values for cast steels is very high; close to the lower critical temperature of the steel. This fact is illustrated in Fig. 32. A Mn-Mo (8320) cast steel was tested after two different tempering treatments following a water quenching operation. It was found that the higher tempering temperature (1275 F) was responsible for the highest impact values at all testing temperatures down to –150 F.

The use of the impact test for determining the acceptability of material does not necessarily insure that such material will be acceptable for the service intended. In other words, the notched-bar impact test does not simulate service conditions. If anything, it is more exacting, as a casting is usually not so severely notched or of as small a section as the notched impact test bar.

If a casting could be tested in impact at low temperatures, it might give a tough fracture when the notched impact test bar of the steel from the casting showed a brittle fracture. Also, castings are usually subjected to repeated stresses in actual service, and the single-blow notched-bar test gives no indication of the notch sensitivity or lack of notch sensitivity. Passing or failing to pass an arbitrary foot-pound specification carries no certainty of endurance or failure of a casting in actual service. However, a uniform test, even though it be an artificial one, is necessary to give an indication of the character of the steel.

The notched-bar impact test is valuable in that it aids the manufacturer in selecting a steel, composition and heat treatment and in controlling the steelmaking conditions that will give high impact values at the particular temperature of testing desired. In view of these statements, it is suggested to the purchaser of steel castings for low-temperature application that his specification carry only a requirement of a minimum notch-bar impact value at a definite temperature, and that the steel foundry be permitted to select the steel and prescribe the steel making and the heat treatment which will meet this requirement.

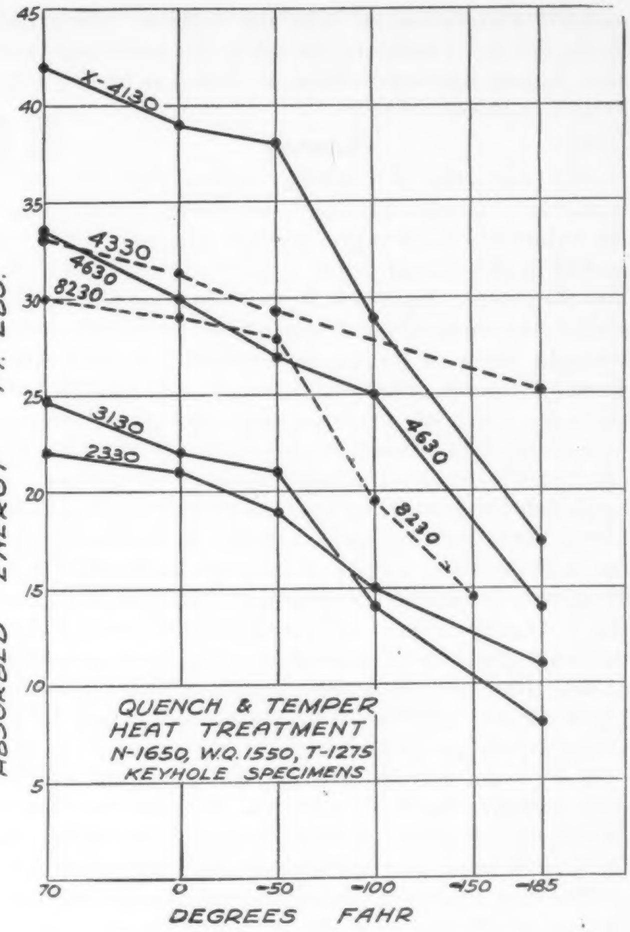


Fig. 31—Comparison of Charpy keyhole impact resistance values at various temperatures for alloy cast steels given a water quench and temper heat treatment.

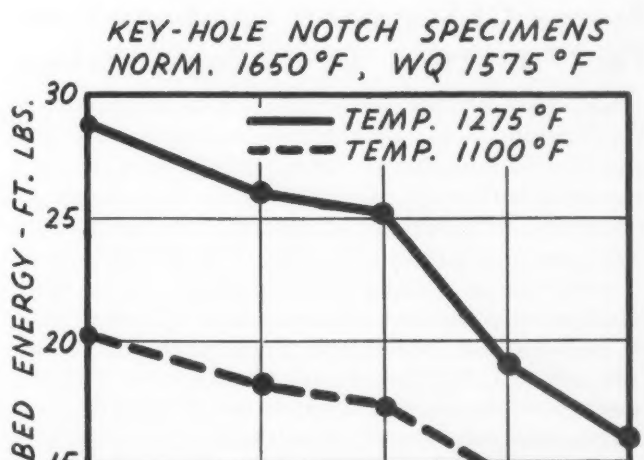
Impact Values of Cast Steels Vs Impact Values of Wrought Steels

Studies of wrought steels by various investigators tend to show that there are considerable differences between impact values obtained from test specimens taken in the direction of rolling as compared with those obtained when the specimens are taken transverse to the direction of rolling. The latter values are usually much lower than the former. The differences are accentuated by steels of high inclusion content and banded structures. Also, it cannot be assumed from notched-bar data on longitudinal specimens of wrought steel that a given piece of wrought steel will behave in the same fashion when the notch and the applied stress come in another direction.

Generally speaking, wrought steels, when tested in the direction of rolling, show higher impact values than cast steels of similar composition. However, cast steels do not show directional properties; hence the notched-bar impact values are greater than those of wrought steels when tested transverse to the direction of rolling. If the two wrought steel values are averaged, they are comparable to the values obtained for cast steels of similar composition. Hence what seem to be low impact values for a cast steel as compared with the most favorable values for a wrought steel, may, in fact, reflect an ability to withstand notches in any direction much better than a wrought steel having large directional differences.

Practically all cast steels used for low-temperature service are deoxidized with aluminum and are fine grained. These steels have ductile fractures at testing

Fig. 32—Effect of tempering treatment on the keyhole notch impact resistance of a water quenched and tempered Mn-Mo (8230) cast steel at various temperatures.



temperatures as low as −150 and −185 F. The trend of the curves of many of the alloy cast steels indicates that ductile fractures would be found at testing temperatures below −185 F.

Summary

The properties of a number of low alloy cast steels have been determined from production heats, hence the values obtained represent the values normally expected in the manufacture of steel castings. The cast low-alloy steels, in general, have slightly higher hardenability and strength, and slightly lower ductility than wrought steels of similar composition, on heat treatment. Property ranges for strength and ductility are given for cast steels receiving different heat treatments.

The depth of section to which cast steel will harden can be estimated by the employment of the end-quench hardenability test. This test was used to study a number of carbon and alloy cast steels. It was found that the hardenability values of cast steels are similar to those of wrought steels of comparable analyses and grain sizes. Hardenability curves for typical carbon cast steels are given and hardenability bands for a number of low-alloy cast steels are illustrated. All degrees of hardenability, shallow to deep hardening, may be attained by the proper selection of cast steels.

Studies on notched-bar impact specimens of cast steel revealed that by varying the structure of a single cast steel by heat treatment, it is possible to change the low temperature notched-bar impact values of the steel.

The best impact resistance for all temperatures investigated (70 to −185 F) is produced by a liquid quench and temper heat treatment. A higher tempering temperature should be employed.

Based upon the results of the investigation, it is concluded that no one alloy cast steel produces the best impact resistance, for all types of heat treatments, at all testing temperatures.

Alloy cast steels demonstrate excellent notched-bar impact properties at low temperatures, which make them ideal for low-temperature service applications.

Bureau Of Standards Conducts Tests For Protection Of X-Ray Workers

Scientists at the National Bureau of Standards, Washington, D. C., are engaged in an extensive program for determining the effectivness of concrete as a protective barrier against million volt wide-beam x-rays, whose use is increasing in industry. At the present time, exact wall thicknesses and most desirable types of construction necessary for maximum short wavelength x-ray protection are not definitely known. One of the basic aims of the new project is to collect data from which the highest degree of protection with the lowest possible cost of installation can be calculated.

Industrial uses for million volt x-ray equipment were greatly increased during World War II when industrial engineers turned to it as a device for detecting flaws in all types of metal. In particular, broad beam x-rays, which allow simultaneous examination of wide areas, came into extensive use. While broad-beam x-rays, ranging in diameter up to four or five feet, are not essentially different (except for the amount of surface covered) from narrowed beam radiation, they pose a special protection problem.

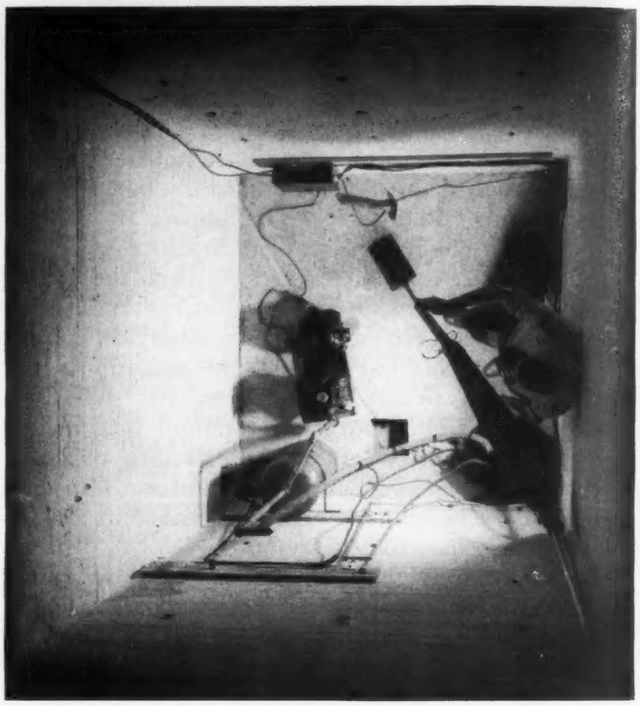


Fig. 1—Radiation pit in which the x-ray penetration measurements are made. Pit is about six feet square and located 20 feet below the target of the x-ray tube.

Institutions using million-volt equipment have been seriously concerned with this phenomena and in order to assure a wide margin of safety have constructed walls of exceptional thickness. Field attempts to make measurements establishing optimum thicknesses and construction characteristics involve so many variables that the entire project, except for final testing, must be carried out in the laboratory, where the variables effecting radiation hazards can be simulated, controlled, and analyzed.

Industrial x-rays are used in three ways for metal examination. Radiographs are obtained by directing beams of x-rays through a metal object and recording the shadow lines on photographic plates. Many examinations of small parts are made by a fluoroscopic screen. A relatively new technique, x-ray diffraction, is a method for studying crystalline structure, where the x-rays are diffracted by the crystals within the metal and are recorded photographically or by means of a Geiger counter.

To determine protection standards, a million and one-half volt x-ray machine in the Bureau's laboratories has been converted so that it will produce beams of varying widths. It is mounted so that it can be directed downward into a "radiation pit" about six feet square and twenty feet below the target of the x-ray tube (Fig. 1). Special instruments, designed to explore the strength of the radiation in the pit, can be shifted to various positions by remote control. Both the control and the x-ray reading equipment are operated from a central control room surrounded by eighteen inches of concrete and located seventy-five feet from the pit.

FEEDING CASTINGS

S. L. Finch
Foundry Mgr.
Catton & Co., Ltd.
Leeds, England

MANY ADVANCES IN FOUNDRY PRACTICE have been made during the past few years. Progress and developments have been made chiefly because the founder realized that foundry practice was not only a craft but that it offered to the scientist a tremendous field of opportunity for research and subsequent development. Not least among these scientific studies has been the analysis of some of the factors influencing the feeding of solidifying alloys. Some of the fundamental laws which govern feeding were established, but these merely revealed the almost complete lack of data on this subject.

Efforts were made during the war years to discover the true facts so that a more complete understanding of this aspect of foundry practice could be established. While considerable success has been achieved, this has led to the realization of just how many variables do affect feeding efficiency. This paper is not meant to give any further experimental or practical evidence of feeding technique but rather is an attempt to correlate certain practices with known theories, and also to offer some theories, which unfortunately cannot be proved or disproved because of lack of data. However, time will reveal these shortcomings, but only co-operative research on a large scale can lift the veil of misunderstanding.

In order that several recent discoveries may be reviewed, it is essential to deal with some of the variables affecting feeding efficiency. It is always a difficult task to name these variables and place them in order of importance, but consideration of the following sections (all of which undoubtedly affect feeding efficiency) will serve as a basis for theoretical assumptions and recommended practices: (A) The mechanization of crystallization, solidification, and subsequent shrinkage; (B) directional solidification and temperature gradient; and (C) flow of liquid from feeder head to casting.

(A) MECHANIZATION OF CRYSTALLIZATION, SOLIDIFICATION AND SUBSEQUENT SHRINKAGE

Although the facts concerning crystallization and solidification are generally well known, it is essential to discuss these in an elementary manner to serve as a basis for further portions of the paper. Additionally, some comments are made in the following paragraphs which reveal the complexity of the problem of establishing efficient feeding. Each of the following has some bearing on crystallization and solidification, and each probably affects feeding efficiency to a greater or lesser degree: (1) the growth of metallic crystals; (2) alloy composition; (3) supercooling; (4) latent heat of fusion; (5) specific heat; (6) gas content; and (7) form of shrinkage.

NOTE: This paper was originally presented at the 44th Annual Meeting of The Institute of British Foundrymen, June 17-20, 1947, at Nottingham, England.

(1) Growth of Metallic Crystals—In considering the crystallization of a metallic liquid the first stage must be the study of metallic growth as it would occur in a mass of liquid whose container would have no effect on crystallization procedure.

In a liquid which is at a temperature considerably above the melting point, the atoms are constantly under the force of repulsion and although contacts are constantly being made, no combination takes place. As the temperature of the liquid drops, the movement of the atoms becomes slower, and the forces of repulsion are decreasing. As the freezing point is approached the atoms have a tendency to combine and to assume their space lattice formation.

This state is, however, unstable, and they have only a temporary existence, and until the liquid temperature falls there is no increase in their stability. As the temperature falls so does the stability of these fragments increase. At a certain temperature this stability is established and the fragments form their appropriate space lattices and attach themselves to other atoms. This stage marks the commencement of crystallization.

Initial Crystal Growth

From the formation of the atomic and foreign nuclei, crystal growth commences. As an example, liquid iron crystallizes in the cubic form and the octahedron appears to be the crystalline form of gamma and delta iron, growth occurring preferentially in the direction of the axis of the system.

Associated with octahedral crystalline growth is the formation of the usual six-branched primary skeleton. While the formation of these branches is caused by the force of crystallization, their cross section is of a circular nature because of the effect of surface tension.

What may be termed the second stage of crystallization is the formation of secondary skeleton branches from the primary ones, and the growth of the former proceeds parallel with those of the latter. Tertiary branches next begin to form and the final crystal formation begins to occur. As all of these branches begin to form two other factors influence crystallization; (a) the initial branches of the skeleton begin to thicken, and (b) the last branches to be thrown out begin to restrict the growth of their neighbors.

Thus two forms of crystallization are possible: (1) the formation of a complete skeleton of primary, sec-

ondary, tertiary, etc., branches surrounded by liquid, or (2) that the thickening up of the branches occurs as quickly as the formation of secondary branches, thus resulting in progressive formation of a solid rather than extensive skeleton growth.

The range between these two extremes is governed by the solidification range of the alloy. Thus with varying ranges of solidification a consistent formation of skeleton growth in the various alloys does not occur and the type of growth will be found to be a compromise between case (1) and (2).

Thus metallic alloys generally solidify first by the formation of skeleton growth and some thickening of the branches, followed by the final stage where liquid metal is supplied before the final stage of thickening to fill all the interstices. It is this last aspect of crystallization which will be found to be most important when related to feeding. This consideration of unadulterated crystal growth must now be considered in the solidification procedure which occurs in a mold.

Crystallization in Mold

When a liquid alloy is poured into a sand mold there is formed fairly quickly a very thin shell of chilled material. It is from this chilled alloy that crystallization first commences. As in the theoretical case, crystalline growth commences by the formation of skeleton branches surrounded by liquid. Thus the primary skeleton branches are surrounded by a liquid of lower melting point.

Skeleton branches are, then, proceeding from the mold face into the center, the interstices being surrounded by metal of lower freezing range which has been slightly heated or at least had its cooling rate retarded by the dissipation of heat from the skeleton branches on solidification. This takes place progressively from the outside of the mold face to the interior. It is this skeleton growth which introduces complications in the feeding of castings.

If solidification was completed by the formation of even layers of solid matter, trouble as a result of inefficient feeding would not be as prevalent as it is. At any stage after skeleton growth has commenced the farthest advanced portion of the solid consists only of crystal skeletons, completely solid metal having formed some considerable distance nearer the cooling mold face. Consequently, the metal in the mold may be divided into three zones:

(1) The solid zone on the outside.

(2) The mushy zone consisting of skeleton crystals in the liquid. (By mushy zone the author wishes to convey the description of liquid plus solid crystals. This should not be confused with viscosity.)

(3) The liquid zone. (It should be pointed out that these zones merge into each other and are not distinct layers.) In pure metals and eutectics which solidify at constant temperatures the second zone is practically nonexistent, and the effect of skeleton growth is at a minimum because of the absence of selective freezing. In solid solutions, the second zone is wider and its width increases with increase in the temperature interval between the liquidus and solidus and with decrease in temperature gradient.

During solidification the three zones may be distinguished as the solid zone nearest the mold face, and this advances with the isotherm representing the solidus; the advance of the second zone keeps up with the isothermal line representing the liquidus. With a given temperature gradient the actual width of the mushy zone must increase with the difference between the liquidus and the solidus, and with a given range of solidification, the width of the mushy zone must increase with decrease in the temperature gradient. The effect of latent and specific heat values will also control the width of the mushy zone.

Surface Area—Volume Ratio

Considering this from the practical aspect, the effect in certain types of castings will be considerably varied. Where the section is thin and uniform and where there is a relatively large surface area to volume, there will be a steep temperature gradient; the mushy zone will be small. As the surface area to volume ratio decreases, so the rate of cooling will decrease and the temperature gradient will be lowered, increasing the mushy zone.

Keeping these two variables in mind, consider the effect of increasing section. The rate of solidification will be decreased and, as a consequence, so will the temperature gradient, resulting in an increased mushy zone. The effect of composition on the mushy zone becomes increasingly obvious in that any added element which increases the solidification range automatically increases the mushy zone, all other variables being constant.

As crystallization occurs in the manner described, a certain amount of "free" growth probably occurs in the core of the section. As these skeleton branches form, as a result of their higher density they tend to drop in the direction of the force of gravity. Recent experimental work carried out by B.I.S.R.A. reveals that this has considerable influence on the mode of crystallization of steel in a mold. Columnar crystals grow from the roof of the mold, while equi-axial or nuclear crystals persist in the lower portion. The latter is caused by the "smothering" effect of falling nuclear crystals.

As skeleton growth occurs, the crystal branches are surrounded by a liquid varying in composition, the degree of variation being purely dependent on the initial alloy. The branches of the skeleton begin to gradually thicken at the expense of the surrounding liquid metal.

Liquid Flow Factors

At the same time the advance of the zone of the skeleton growth continues. As the liquid surrounding the skeleton branches solidifies it contracts in volume, and thus the voids must be filled by metal which is filling the interstices of more recently born skeleton growths. This in turn must be compensated by the flow of liquid from the interior, but, as will be shown later, many factors probably control this flow.

This procedure continues until finally the skeleton branches from opposite or adjoining mold faces meet and the interstitial spaces are filled by metal flowing from the portion of the mold which still is liquid. It is realized that more advanced theories concerning crystallization are under consideration, but these will

not in any way alter the general principles. This very elementary outline of crystallization had, however, to be given as a basis for certain theories which are considered in this paper in relation to efficient feeding.

(2) Alloy Composition—Feeding potentialities and complexities are not affected by alloy composition. The effect of composition on fluidity has been sufficiently studied to give some conclusions. Bastien [5] proved that the fluidity of a series of alloys varies inversely with their respective solidification ranges. Pure metals and eutectics of a series have the best fluidity, while saturated solid solutions are relatively lower. Consequently, other variables being constant, alloys approaching pure metals or eutectics have a higher fluidity, and are easier to feed than alloys which consist of saturated solid solutions.

While alloy composition governs solidification range, it also controls the amount of liquid and solid present at different stages during solidification. The effect of

TABLE 1—CONSTANTS USED IN THE LATENT HEAT OF FUSION OF VARIOUS PARTS

Metal	d	c	L	L x D	$\frac{L \times d}{F-15}$
Al	2.3	0.22	76.6	183	0.29
Zn	6.9	0.12	26.5	182	0.46
Sb	6.5	0.07	41.0	256	0.41
Cd	8.6	0.06	13.0	112	0.37
Sn	6.9	0.05	14.0	96	0.44
Pb	10.8	0.03	5.5	59	0.18

increase in solidification range does, of course, increase feeding problems, as can be gathered from the discussion on crystallization as well as its effect on fluidity. Obviously, the greater the distance between liquidus and solidus, the greater the mushy zone.

However, what crystallization studies do not at first reveal is that the greater the amount of liquid present in a solidifying alloy, the less microshrinkage that occurs as a result of the dendritic growth. Consequently, two different alloys which have the same solidification range may differ considerably in soundness. This is because of one having at the lower end of the solidification range a greater amount of liquid present, the other alloy having a larger amount of solid and less liquid; consequently, the latter alloy is more prone to microshrinkage.[1]

These two factors affect the solidification range and the shapes of the liquidus and solidus lines have been proved experimentally. Indeed, it was shown in the case of magnesium alloys that although one alloy had a shorter solidification range than another, it was more susceptible to microporosity because it contained far less liquid in the lower portion of its solidification range.

(3) Supercooling—The phenomena of supercooling is fairly well understood. Undercooling of alloys does occur, but to what degree has not been ascertained. Rapid cooling encourages supercooling, and thus in thin sections a considerable degree of supercooling may take place. The fluidity of an alloy under these conditions may well affect feeding efficiency. Perhaps some research worker may eventually be able to shed some light on this unknown variable.

(4) Latent Heat of Fusion—On crystallization, heat is evolved because of the change of state from liquid to solid, and the values for latent heat of fusion of some metals are given in Table 1. How latent heat of fusion affects feeding efficiency is a matter of conjecture, but it is of general interest to study the work of Bastien [5] on the relationship between fluidity latent heat, density, and the temperature of solidification.

Bastien revealed that:

$$\beta \text{ is proportional to } \frac{L \times d}{F - 15}$$

where

β = length of spiral cast at a constant temperature above the solidus
L = latent heat of fusion
d = density
F = temperature of solidification
15 = temperature of mold . (All temperatures in degrees C.)

Table 1 gives the constants used. Order of fluidity by calculation is Zn, Sn, Sb, Al, Pb, and actual experimental work using the spiral test piece gave the fluidity order of Sn, Zn, Sb, Cd, Al, Pb.

(5) Specific Heat—Again reference should be made to the work of Bastien [5] on fluidity. He revealed that

$$\beta \text{ is proportional to } c \times d$$

where β = length of spiral cast at a constant temperature above the solidus, c=specific heat, and d=density. Table 2 shows the constants used. The experimental work confirmed the calculations made by the investigator. Fluidity is probably the most important factor in feeding efficiency, and therefore this study of specific heat should not be neglected.

(6) Gas Content—The fact that gases are present in a greater or lesser degree depending on certain variables is accepted. As gas is more soluble in liquid metals than

TABLE 2—CONSTANTS USED IN CONNECTION WITH SPECIFIC HEAT

Metal	c	d	c x d
Sn	0.05	7.3	0.37
Sb	0.07	6.6	0.46
Pb	0.03	11.3	0.34
Cd	0.06	8.6	0.55

their solids, it must under normal conditions mostly come out of solution on solidification. A great amount of literature has been written on the solubilities of certain gases, but this paper is limited to feeding, and this section to the effect the presence of gas in the metal has on its feeding characteristics.

Actually, what occurs in solidification is that crystallization begins to take place and crystal growth commences. As the relative concentration of gas becomes so high in the solidifying portion as to be supersaturated, then some of the gas is given off. More and more gas is given off from surrounding material that is solidifying, and as this bubble growth is taking place, so is crystallization proceeding. The bubbles form around

the crystals which have given birth to this gas, and as a result are forming continuously in the interstices of ingrowing crystals.

As crystal growth proceeds, these interdendritic voids are formed because the evolved gas sets up an equilibrium with the feeding pressure. Feeding liquid is prevented from entering these voids because of the positive pressure set up by the evolved gas. This is a complex problem and further reference will be given to this aspect under the heading "Flow of Metal."

Crystal and bubble growth take place simultaneously, and unless the gas pressure in the voids is overcome and finally filled or partially filled by feeding metal, then crystal growth will finally seal in the gas bubble, giving rise to sponginess and increasing porosity. All of this theoretical explanation has been carefully proved by experiments, and many references can be made.

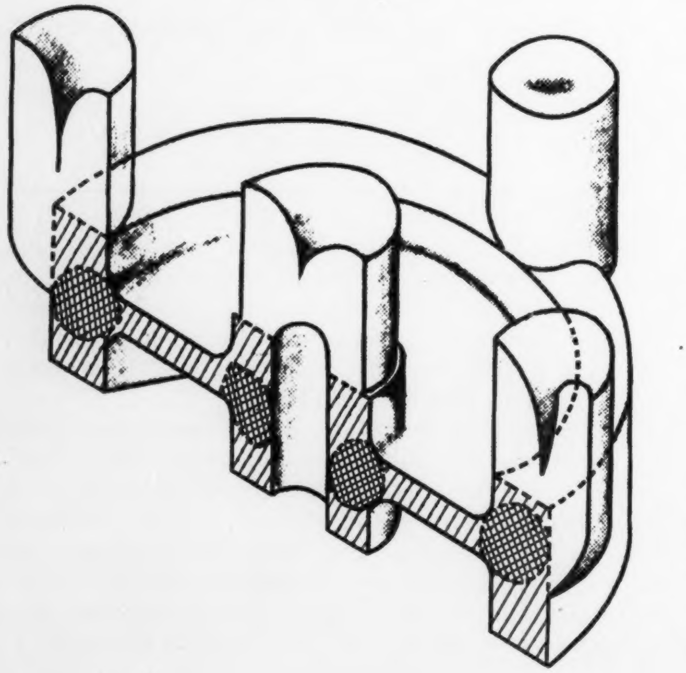
The presence of gas in an alloy now becomes one more variable which controls feeding efficiency. Such things, then, as good melting and fluxing practice have an indirect bearing on feeding efficiency. Obviously, bubble growth only takes place in gassy metal, and therefore the statement concerning bubble growth should be treated as very general, and must vary according to the quantity of gas evolved during solidification.

Certain alloys have been shown to receive beneficial results because of the presence of a small quantity of gas. Instead of local sponginess in certain areas, an optimum gas content breaks this up into very minute porosity throughout the casting. The question of whether to aim for efficient feeding or optimum gas content is debatable, but the former is more practicable.

(7) Forms of Shrinkage Cavities—There are several forms of shrinkage which occur in castings, whether made in steel, aluminum, magnesium or bronze. Broadly speaking, these can be split into two main groups: (a) macro- and (b) microshrinkage.

(a) Macroshrinkage—This form of shrinkage is a result of shortage of feed metal, and the result—cavities, visible to the naked eye, varying in size of course as related to the shortage of feed metal. This shortage of feed metal may not, however, be a result of small feeder heads. Balanced systems of feeding are essential in good feeding technique, and unless this is established, only excessive amounts of feeder heads will overcome the trouble. Having balanced feeding systems it may be said generally that major shrinkage can be overcome by correct gating and feeding technique.

Fig. 1—Sketch of gear block casting.



(b) Microshrinkage—This looseness of structure is a result of interdendritic voids, and many variables control its occurrence and concentration. These variables are such things as solidification range, contour of liquidus and solidus, gas content, etc. The methods of overcoming this porosity depend on its cause, and are studied in other paragraphs in this paper.

Other forms of shrinkage do occur. For instance, centerline shrinkage in steel could hardly be termed microshrinkage, and yet it is a result of the meeting of ingrowing crystals. This midwall shrinkage consists of interconnected voids occurring more or less in the center of solidifying mass where side-wall effects have been pronounced.

Shrinkage and Properties

This centerline shrinkage has two characteristics; (a) position, and (b) direction. In vertical planes this shrinkage occurs in the center, while the more a section approaches the horizontal the more the tendency of this centerline shrinkage to move nearer the top face. The formation of these voids usually is of the V type, and points away from the feeder head.

The influence of centerline shrinkage, of course, is to decrease mechanical properties and also to make castings unsound to hydraulic pressure tests. This centerline shrinkage usually can be overcome by using the general principles of directional solidification. A form of microshrinkage presenting many foundry problems is caused by hot spots. The occurrence of hot spots is a continual source of annoyance, and chills or possible re-design can be used to help reduce the problem.

(B) DIRECTIONAL SOLIDIFICATION AND TEMPERATURE GRADIENTS.

(1) Principle of Directional Solidification—A considerable amount of literature has been written on directional solidification. Briefly, it consists of progressive solidification at the point most distant from a feeder head, final solidification to take place at the base of the head. This simple statement is, however, not always easy to achieve because of such factors as casting design, method of casting and feeding most practicable, occurrence of hot spots, etc.

In itself, directional solidification can be broken down into basic principles, and some of these will be considered in the following paragraphs. Some proved and recommended methods of achieving progressive solidification will be mentioned, but it is not possible to cover all methods of obtaining this. The better known include top gating and feeding, step gating, and pouring directly into the riser by means of pencil gates.

(2) Casting Design and the Heuver Method of Planning the Feeding Method—An example of a common casting which although relatively simple in design gives

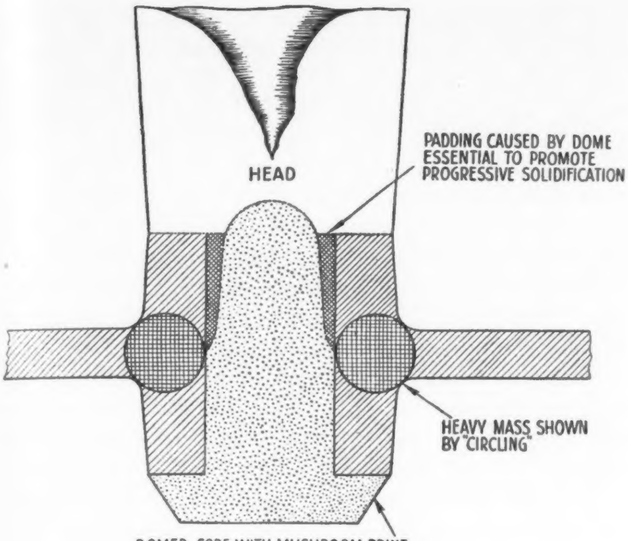


Fig. 2—Unusual core shape used to advantage.

considerable trouble because of shrinkage cavities and porosity showing after machining, is a gear blank as shown in Fig. 1. Using Heuver's circle method of illustrating the thickest section which will require feeding, it is found that the portion of the casting connected to the web, both in the boss and rim, is greater than in any other portion.

If the orthodox method of feeding, i.e., top heads be used, these must be heeled down in relation to the circle indicating the maximum section. The method is shown in Fig. 1. Note the unusual shape of the center core in Fig. 2 necessary to give even section to the maximum section to be fed. With the use of this method, however, while the center boss was always found to be sound, a considerable amount of porosity occurred in the rim. To overcome this, the principle of directional solidification was used and two whirlgate atmospheric heads were substituted for the four top heads on the rim.

Figure 3 shows the method and illustrates a section of the rim and head indicating the Heuver method of "circling" to show where it is essential for maximum feed. The use of this method of circling is useful to designers of castings as well as to the foundryman, and could be used by those who understand feeding technique to prevent problems ever reaching the foundry. Figures 4 and 5 illustrate an example of a modified design of hub casting, using the Heuver principle.

(3) Pronouncing Directional Solidification by the Use of Insulating Material [2] *for Feeder Heads*—A casting with a 60 per cent yield required a feeder head of 40 per cent, this feeder head being made up of (a) the mass of metal required to offset premature freezing of the head, and (b) the quantity of metal to compensate for liquid shrinkage in the alloy.

Assuming that this latter requirement is 10 per cent, then 80 per cent of the feeder head is used to prevent, by mass effect, its premature freezing. This means that only 20 per cent of the feeder head is used for liquid shrinkage requirements. A simple deduction from this observation was that if the rate of solidification of the feeder head could be retarded, then the mass of metal required to offset premature freezing could be reduced.

One method of doing this is to use insulating pads around the risers. This has been done in steel by using a 10 per cent sawdust addition to the sand, and in bronzes by the use of gypsum pads. Feeder efficiency is greatly increased, and although no figures are available for steel, yields of over 80 per cent have been recorded with the bronzes. This idea is particularly interesting to the non-ferrous founder who, in his efforts to reduce turbulent gating, is often faced with the necessity of using large top heads in order to promote progressive feeding.

Insulated Feeder Heads

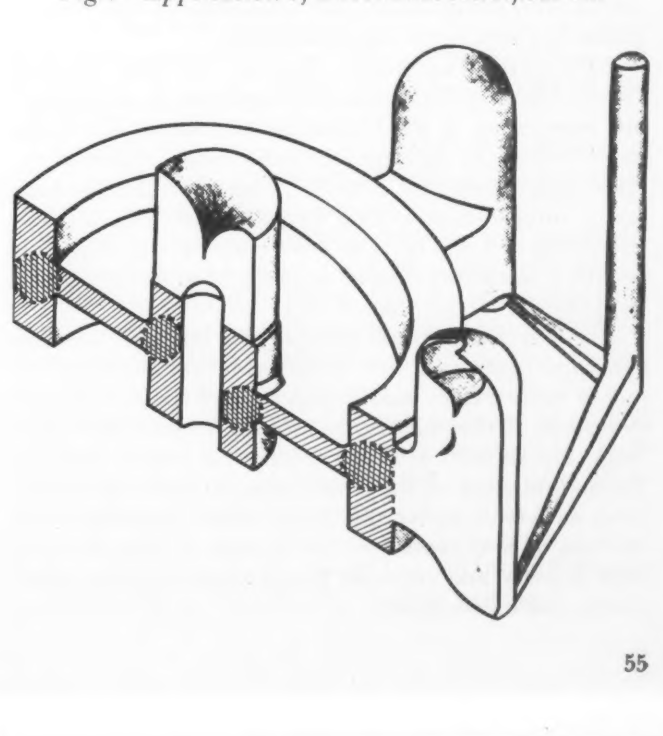
Manganese and aluminum bronze castings are noteworthy in this respect, and gypsum-insulated heads have proved most effective in increasing feeder efficiency and improving yield figures, in some cases by as much as 75 per cent. Because of the slow lateral solidification of the feeder head, the shrinkage cavity in insulated feeders is globular, and sometimes practically flat bottomed, thus reducing wastage to a minimum.

(4) Use of Exothermic Material (a) In, and (b) Around Feeder Heads—Various liquefiers and feeder powders are on the market today for use in ferrous and non-ferrous feeding technique. Two new advances in the United States, however, would appear to have great advantages over these materials. The first is used inside a feeder head and the second is molded around the feeder, but can also be used inside.

(a) Exothermic Compounds to Be Used Inside Feeder Head—The preliminary work on this subject was completed at the Boston Navy Yard. Tests were completed for steel and monel and illustrate the usage of exothermic materials in concentrated form in risers, thus providing great heat to promote directional solidification.

In exothermic reactions the properly sized powders of oxides of metals react with aluminum powder to produce the metal of the oxide, aluminum oxide, and, of course, the generation of intense heat because of this chemical reaction. The chemical formulas for the gen-

Fig. 3—Application of directional solidification.



eral reactions for steel, monel metal and bronze applications would involve some or combinations of the following:

$$3\ Fe_3O_4 + 8\ Al = 4\ Al_2O_3 + 9\ Fe + \text{Heat.}$$
$$3\ NiO + 2\ Al = Al_2O_3 + 3\ Ni + \text{Heat.}$$
$$3\ CoO + 2\ Al = Al_2O_3 + 3\ Cu + \text{Heat.}$$

This type of reaction provides the two basic antishrinkage aids, i.e., the production of superheated metal in the riser, where heat is most desirable, and production of an insulating material on the surface of the riser to prevent heat radiation. The method used by these investigators was to fill the feeder head with exothermic compound instead of the liquid alloy. This resulted in superheated metal of very high fluidity being in the heads.

On final solidification the heads were found to be of the flat-bottomed type, and yields of 80 per cent were obtainable. More work has still to be done on this subject, and consequently its practical value has not been fully investigated. Its use, however, may be limited to one of alloy composition, but undoubtedly this investigation is a step in the right direction.

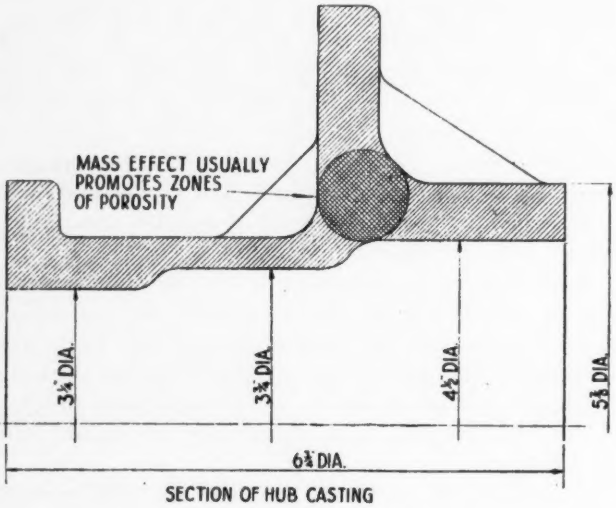


Fig. 4—Modified design using the Heuver method.

(b) Use of Exothermic Material Molded Around Feeder Head —The recent development of an exothermic compound in the United States promises to cause some revision of feeding methods. The compound relates to an exothermic material, which it is claimed generates intense heat over a period which can be controlled up to 4 or 5 hr. Once the material has burned it becomes refractory, quite capable of standing up to temperatures above that of steel.

The reactive material consists of a composition that generates heat as a result of the oxidation of a metal by one or more oxides modified to control the rate of heat evolution. If this material is molded around the feeder head, the amount of heat evolved will either result in the maintenance of the casting temperature within the head or raise it above this temperature, dependent on the rate of heat evolution. As a result of this, metal of high fluidity and constant composition is maintained within the feeder head.

A further modification can be made to the feeder head in that the connection of the head can be considerably reduced in size by the use of this exothermic material. The development of this compound would appear to have considerable possibilities in that it makes it possible to retard the solidification rate of a thin section so that feeding can take place through this section.

(c) Flow of Metal From Feeder Head to Casting—As liquid shrinkage takes place within the casting, so must metal flow from the head to compensate for this shrinkage. This is not a simple movement, but is a complex flow governed by such variables as fluidity, friction of crystal growth and head pressure. As flow of compensatory liquid must take place to avoid both macro- and microshrinkage, these variables will be studied as related to feeding technique.

(1) Friction of Crystal Growth—The flow of liquids in smooth pipes has been extensively studied, and it has been found that this flow takes place not uniformly throughout the container, but at a higher velocity in the center, this being a result of wall friction. Reverting to crystallization, one can readily appreciate the effect of crystal growth on liquid flow. The velocity of metal flow in the region of crystal growth will be considerably retarded, if not completely arrested.

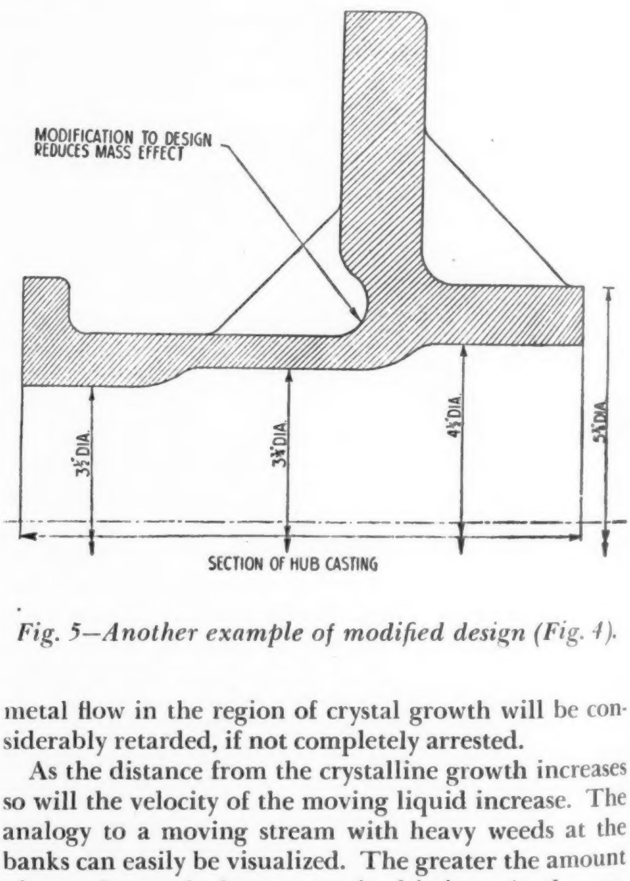


Fig. 5—Another example of modified design (Fig. 4).

As the distance from the crystalline growth increases so will the velocity of the moving liquid increase. The analogy to a moving stream with heavy weeds at the banks can easily be visualized. The greater the amount of crystal growth the greater the friction. As the proportion of solid to liquid increases, so according to this supposition will feeding difficulties increase. This has been proved experimentally, and has previously been discussed under alloy composition.

(2) Surface Tension—Because of the complexities of temperature and necessary apparatus for experiments, the values of surface tension in metals are extremely vague. Whether surface tension does or does not affect feeding efficiency is pure conjecture.

(3) Fluidity—The ability of liquids to flow has been proved to be dependent on composition, latent and specific heats. Figure 6 illustrates a general relationship between temperature and fluidity, but this is only intended to illustrate the trend of fluidity at various temperatures. What is shown by experimental work is that there is a decrease in fluidity as the solidification temperature is approached.

A considerable proportion of the liquid interior of a solidifying casting is at the solidus temperature, but its solidification is arrested by the generation of heat crystallization. It would be interesting to measure the fluidity at this stage, as additionally this liquid of low fluidity is in the region affected by friction of crystal growth.

Recent work by the author has shown the effect of high head pressure on fluidity. Although proof of the general statement is difficult to assess, a relation between fluidity and applied head pressure at constant temperatures appears to exist. Where two variables such as temperature and pressure exist, the tendency of the curve for fluidity will be as shown in Fig. 7. This is only an illustration, and is not a diagram of an actual alloy. Much more could be written on fluidity, but it will be sufficient at this stage just to bear in mind the effects of temperature, pressure, wall friction, latent and specific heats.

In the section on crystallization it was shown that, for efficient feeding to take place in order that microporosity be avoided, interstitial liquid had to flow through the branched skeletons. A theory is now suggested regarding this flow, and will again be considered under segregation. As fluidity is an essential of this liquid flow through the interstices, it is possible that

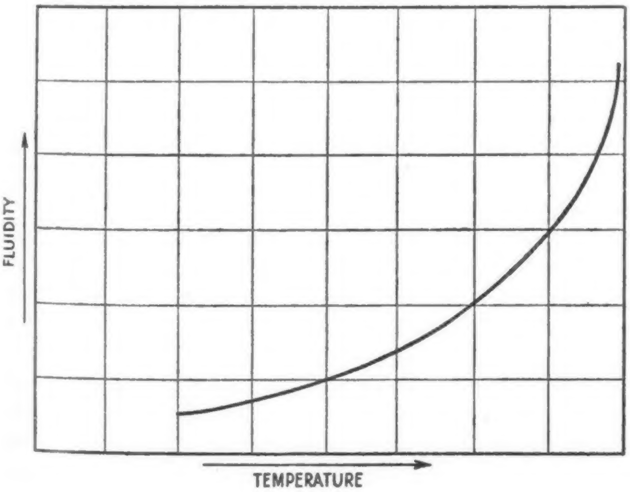


Fig. 6—Chart showing the general relationship between temperature and fluidity.

instead of a gradual movement of liquid from the edge of the isothermal representing the liquidus to that of the solidus, quite a different movement may take place.

As the branches of the skeletons thicken at the expense of the surrounding liquid, voids will occur unless the fluidity of the interstitial liquid in the adjoining skeletons is such that this flow will not take place. The author believes that this is what actually occurs in some alloys. Thus voids are present, possibly filled with gas in a badly prepared melt, but otherwise a partial vacuum exists.

As solidification has been proceeding so has normal diffusion and segregation been taking place. Now instead of a gradual displacement of interstitial liquid, it is thought that in certain cases the skeleton branches thicken as much as possible on the surrounding interstitial liquid of low fluidity and leave voids which are eventually filled by the segregate, which has relatively high fluidity.

In connection with the theory of pressure effect on fluidity, one can visualize that instead of waiting for the segregate to fill the voids, in pressure-fed castings there should be, as a result of this relative improvement in fluidity because of applied pressure, a continuous displacement of interstitial liquid. One major effect of this theory will be on segregation and will be discussed in the appropriate paragraphs.

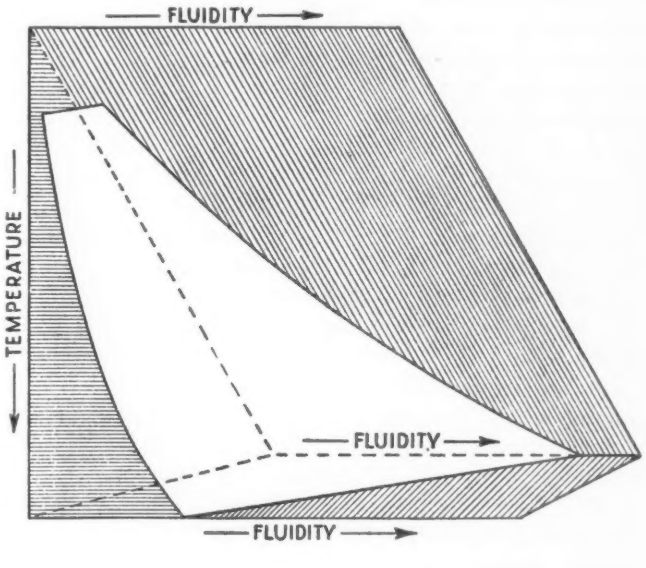


Fig. 7—Diagram showing trend of fluidity curve.

(4) Actual Flow of Feeder Metal—To cause metal to flow from a feeder head to casting interior an applied force must be used. These are three in number and consist of:

(1) Gravity; (a) hydrostatic, and (b) hydrostatic plus atmospheric; (2) centrifugal force; and (3) head pressure greater than atmospheric.

(1) (a) Hydrostatic Pressure—This force is purely dependent on head weight. *(b) Hydrostatic Plus Atmospheric*—The advent of the Williams riser revealed the full benefits that could be achieved by the utilization of higher pressures. Sufficient information is at hand on this subject and there is no need to add to this.

(2) Centrifugal Force—The development of special equipment brought into use higher pressures for feeding, although this is by no means the only factor affecting feeding efficiency in centrifugal casting.

(3) Head Pressures Greater Than Atmospheric—Evolution of gas in feeder heads has led to still higher pressures being available for feeding castings.

These various pressures should now be analyzed without considering economics, but purely limiting the outlook to one of feeding efficiency. Low pressure will cause a flow of metal from the head to the casting while the fluidity of the liquid is fairly high, and in the region where there is no interference with crystal growth. At the same time it will be insufficient to cause the forcing of liquid metal into the smaller interstitial cavities, particularly as the liquid in this region is obstructed by crystal growth and is of relatively low fluidity.

High Pressures

Obviously, forces are needed which will overcome this low fluidity value and friction because of crystal growth, and it is only by the use of atmospheric, centrifugal and other high pressures that this liquid will flow into the interdendritic voids. Occasionally the effect of gas evolution has also to be overcome and, as this develops a positive pressure, its effect must be nullified before efficient feeding takes place in alloys which are unduly gassy.

In the latter case it may be of interest that Hanson and Slater have shown that if gassy aluminum alloys are cast in sand molds under an air pressure, pinholes are reduced in size and ingots of high density are obtained. With most aluminum alloys a pressure of 50 psi is all that is required to remove all visible pinholes from a 2x2 in. ingot. The effect of pressure is to prevent the growth of the gas bubbles, and as a result the cavities are much smaller and probably contain gas under pressure. The effect of all this on mechanical properties has still to be studied, and present research may reveal the true effect of reducing microporosity by pressure feeding.

Before leaving this question of metal flow, the idea of increasing feeding efficiency by improving the relative fluidity between head metal and casting merits further consideration. If, for instance, an exothermic compound surrounding the head metal maintains this at its existing temperature during solidification of the casting, immense improvements should be made in reducing macroporosity because of the ability of head liquid to flow readily under lowered forces.

Feeding Efficiency

Additionally the value of emphasizing the effect of directional solidification and heat transfer will also improve the feeding efficiency, as was noted in earlier paragraphs. Although the effect of insulating heads is not anywhere near as effective, it does serve to increase the relative values of fluidity between feeder head metal and casting.

(5) Segregation—This subject has filled volumes, but it was felt that as segregation is associated with the mechanism of freezing it may be of general interest to study certain aspects of it as related to feeding.

(a) Normal Segregation—This type of segregation usually is found in V segregates pointing away from the feeder head, increasing in intensity toward the feeder head. During solidification it has been claimed that a certain amount of segregates, because of their lower specific gravity, tend to flow upward to the feeder head. A certain amount of segregation also occurs in the feeder head, so that although the tendency for flow toward the feeder head may occur, it is doubtful, as the rate of feed demand causes a flow of liquid from the feeder head to offset the formation of shrinkage in the castings.

Where ingrowing crystal growth meets, and a considerable volume of mushy material exists in the center of the casting, the inward flow of liquid from the feeder head, unless its relative fluidity is high, does not readily take place. This fluidity can be obtained by (1) use of new exothermic or insulating materials, (2) application of pressure, and (3) waiting for the formation of a low-melting point segregate of relatively high fluidity. Where there is a considerable mushy zone and orthodox methods of feeding are used, it is quite obvious that the latter feeding action through the interstices of the ingrowing crystals must take place. This will result in emphasizing the effect of segregation.

Theoretically there are two ways of slightly reducing this excessive segregation caused by the feeding action: (1) To maintain a liquid of uniform composition in the feeder head at a degree of fluidity which will allow it to flow readily through any interstices of ingrowing crystals, or (2) increasing the relative fluidity by the application of pressure. The first can be accomplished by the use of exothermic materials or insulating pads, and the second by the use of pressure methods of feeding. Further research on pressure feeding methods, using highly efficient exothermic materials, may, however, give still better results.

Mechanism of Segregation

(b) Inverse Segregations—Many theories exist concerning the mechanism of inverse segregation. The effect of gas evolution, crystallization characteristics, etc., all probably have a bearing on this form of segregation, but the mechanism of feeding does have a considerable effect. While not wishing to confuse the issue, it may be useful to refer back to the paragraphs dealing with the flow of liquids and consider the formation of microporosity.

In this section a theory was advanced to explain the flow of interstitial liquid and how this may not be a continuous movement, but rather a periodic movement determined by the fluidity of the segregate in front and between advancing crystal growth.

If, as discussed previously, the relative fluidity of the interstitial liquid could be raised by the application of pressure heads, then a gradual and smooth flow of interstitial liquid might take place. This would lead to a more normal segregation and reduce the effects of inverse segregation. This theoretical aspect of pressure feeding against inverse segregation requires a considerable amount of proof, and at the time of writing there is no evidence to support the theory other than the deduction made from existing theories and practices.

One can appreciate that while other factors undoubtedly play their part in normal and inverse segregation, application of more modern methods of feeding may reduce these effects. However, a tremendous amount of work must be done to give the necessary conclusive evidence.

(6) Rate of Feed Demand—The expression "rate of feed demand" has been used somewhat loosely but describes the rate at which feeding metal flows from

the head to the casting. This is dependent on several variables, but the chief one is that of ratio of surface area to volume. The following notes deal specifically with steel, but a general interpretation can be used for other alloys. Chorinov's [4] observations lead to the formation of the formula

$$T = 0.02\ (V/A)^2$$

where T = time for complete freezing in minutes.
V = volume in mm units.
A = surface area in mm units.

While this equation has been proved slightly incorrect, for all purposes it has been accepted as a practical formula.

Thus, if one considers a cube of 1,000,000 cu mm and a surface area of 60,000 sq mm, the time for solidification will be:

$$T = 0.02\ (V/A)^2$$
$$= 0.02 \left(\frac{1,000,000}{60,000}\right)^2$$
$$= 0.02 \left(\frac{100}{6}\right)^2$$
$$= 5.5 \text{ min or } 330 \text{ sec.}$$

Again, consider a mass of 1,000,000 cu mm, but a surface area of 200,000 sq mm, the time for solidification will be

$$T = 0.02 \left(\frac{1,000,000}{200,000}\right)^2 \text{ min} = 0.5 \text{ min or } 30 \text{ sec.}$$

In both cases 1,000,000 cu mm solidifies and, assuming a 6 per cent total liquid shrinkage, 60,000 cu mm of feeding liquid will have to flow from the feeder head to the casting. Where the surface area is 60,000 sq mm the average rate of feed will be 10,909 cu mm per min, while when the surface area is 200,000 sq mm the average rate of feed will be 120,000 cu mm per min, although this will be only for half a minute.

Surface Area to Volume Ratio

Thus it will be seen that although an equal volume of metal is fed, the rate of feed demand of one is approximately twelve times as great, and additionally only one takes place for 30 sec, while the slower flow takes place over approximately 330 sec. Bearing this in mind, one can readily appreciate that with castings of large surface area to volume ratio there will be a greater rate of feed demand than with bulky castings having a small surface area to volume ratio. This has a direct bearing on the economical aspect of feeding. A feeder head is principally a vessel which must remain liquid longer than the casting, and additionally must supply the metal caused by the liquid shrinkage of the casting.

Consider, then, two castings of volume 1,000,000 cu mm, one having a surface area of 60,000 sq mm and the other 200,000 sq mm. The first solidifies in 330 sec and therefore the head feeding this casting must remain liquid for more than 330 sec, and additionally contains the 60,000 cu mm of liquid feed metal. In the second case, the casting solidifies in 30 sec and consequently the head need only remain liquid for just over this period, and additionally, of course, contain the 60,000 cu mm of liquid feed metal.

Consequently, it is quite clear that a much smaller feeder head will be required in the latter case, giving a better yield, as both castings are of the same weight. A further point to note is the shrinkage cavity of the feeder head. For constant pressure and applied heat, the small feeder head for the second casting will have a more globular shaped cavity than the one in the first case as result of the fast rate of feed demand and the fact that in 30 sec there will be little lateral solidification of the walls of the feeder head.

In the matter of yields, the illustration in Fig. 8 shows the tendency of yields for a constant weight of

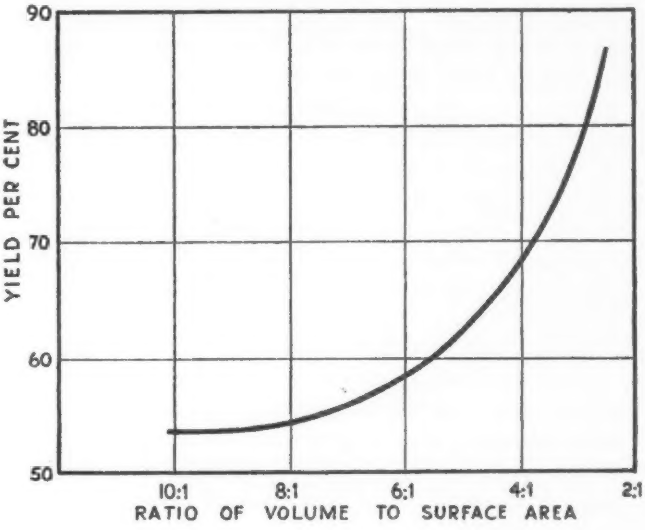


Fig. 8—Chart showing percentage yield in relation to ratio of volume to surface area.

metal having varying ratios of surface area to volume. While only indirectly connected with the flow of liquid metal, it is of interest to note that, by increasing the rate of feed demand by feeding two or more castings from one feeder head, a considerable increase in yield may be obtained. Considering the principle that a feed head must remain liquid longer than the casting and additionally contain the feeder head metal, one usually finds that by far the greater amount of feeder head is used as mass effect in preventing solidification before the casting freezes.

As an example, a casting of 60 per cent maximum theoretical yield uses a feeder head of 40 per cent its own weight. Assuming a shrinkage figure of 5 per cent, it is readily seen that 89 per cent of the feeder head is used to promote the slower freezing of the feeder head. Considering this casting, now assume that three are to be fed off one head. As before, 40 per cent of the mass of one casting must be used to offset premature freezing of the head, and again, assuming 5 per cent shrinkage, 5 per cent of the total weight of the three castings must be added to this feeder.

Thus, assuming 1 per cent as unity, the feeder head capacity will have to be 40 plus 15 for three castings of total weight 180. The yield per casting is now approximately 76.5. Thus to increase yields it is advisable to feed as many castings with one feeder as is practic-

able. Conversely, for high yields it is recommended that the use of one large head is more economical than two slightly smaller heads, assuming, of course, that feeding can be completed with one feeder head.

An observation made when making two or more castings off one feeder head was that the rate of feed demand doubled or trebled as the case may be, and consequently the greater the rate of feed demand, the more globular shaped is the shrinkage cavity in the feeder head.

Possible Feeding Methods

Looking back over the past ten years, one can appreciate the developments and improvements made in feeding technique. The author wishes to look forward and view the possibilities of still further improvements that can be made in feeder efficiency. It appears that one main factor in feeder efficiency is the ability of the metal to flow readily from feeder head to a portion of the shrinking casting. Providing that the liquid has the necessary fluidity either because of temperature or pressure, then this ready flow will take place.

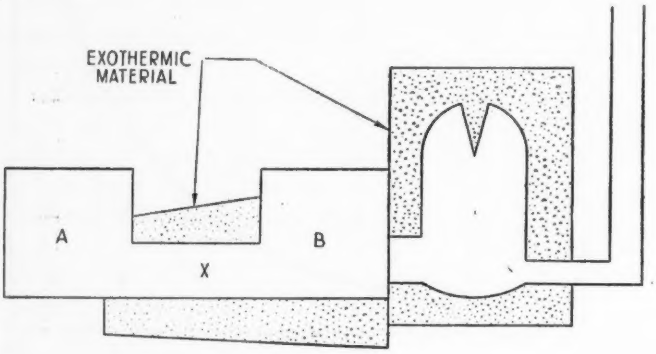


Fig. 9—Sketch showing application of exothermic molding material for efficient feeding.

An elementary conclusion to this is that if the head metal could be maintained at the fluidity of its casting temperature, then feeding efficiency would be greatly increased. Possibly in a few year's time the industry will see the majority of feeder heads maintained (or even raised above) their casting temperatures by the application of heat energy to this feeder.

This can now be done (1) by electrical energy or (2) by the new American patent refractory compound which has a very strong exothermic reaction. Additionally this latter material can be molded to shape around the region of the feeder head. Possibly atomic energy, whose tremendous forces at the moment overshadow the world, can be turned to generating heat in the region of a feeder head.

Having then maintained this fluidity, the ability of the metal to flow will be considerably increased, and therefore it is a matter of conjecture what feeding pressure will be applied in feeder heads. It is possible that some form of pressure feeding, either in its present form or some derivative, will still be used in the foundry industry, but this would depend entirely on the effect of increased feeder fluidity obtained by the application of heat energy, and additionally whether macro- or microshrinkage was prevalent.

At the time of writing, however, it would appear that there is a field for a practical method of pressure feeding to overcome microporosity and possibly reduce inverse segregation. Good feeding technique, combined with the use of atmospheric pressure, is sufficient to overcome macroporosity.

So far the only thing that has been considered has been the methods of making metallic liquids flow from feeder heads to voids in a casting. Next comes the question of economics. As heat energy would enable the founder to use feeder heads of practically theoretical value, the main improvements in yield could then only be affected by reducing the number of heads to one. Additionally, this would reduce cutting and fettling costs considerably. To use only one head means that a method of feeding through any thin sections to any thick section must be achieved.

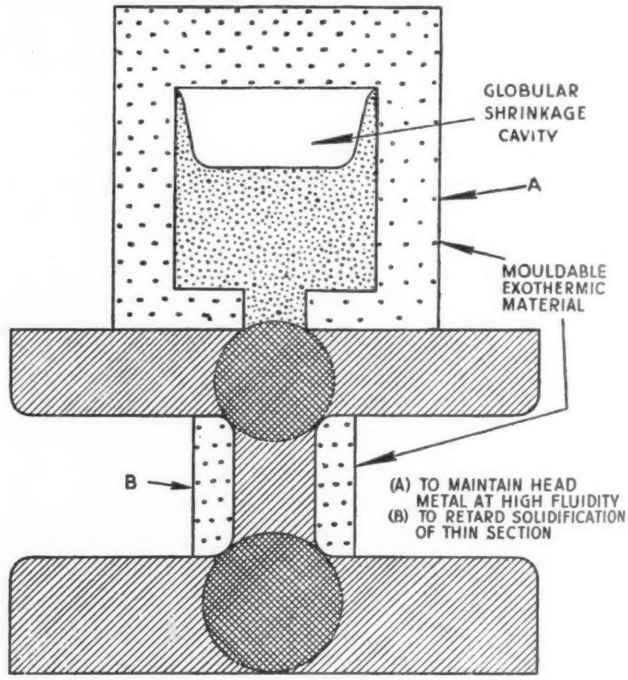


Fig. 10—A further application of exothermic material.

Although but little work has been done on this in the foundry industry, the author believes this to be a possibility. For instance, take the cubes shown in Fig. 9 to illustrate these thoughts. If a casting method as shown could be used (assuming heat energy is supplied by some force to the feeder head), then to feed cube A through restriction X, the solidification of X must be reduced, so that as A solidifies X is still just liquid, but will solidify before B.

It is a possibility that an exothermic refractory material could be packed around section X so that this remained liquid sufficiently long to allow the metal to flow from the head to section A via the thin section X. Whether this will be general practice throughout production cannot be even estimated at the present time.

A simple illustration of how this could be used in

production is shown in Fig. 10. The relatively small top head would be kept fluid by the application of heat energy, while the restricted neck at X would be insulated against quick freezing by surrounding it with a refractory, moldable exothermic mixture which would delay its solidification greater than portion A, but less than portion B.

A further illustration of this method is shown in Fig. 11. At first these methods seem quite unorthodox, but the reader must remember that this discussion is about foundry practice some years hence. It is possible that by then the application of scientific knowledge to all feeding problems will be an everyday fact, and that the subject as just described will be by no means as complicated and haphazard as it has been presented.

The author wishes to apologize for this brief survey of possible future feeding methods, but, on the other hand, some person may be able to put these thoughts to practical use and thus shorten the period between the present haphazard method of feeding castings and the time it can be reduced to a mathematical problem based on heat and pressure energy supplied to various sections of the casting and feeder heads. Until this time arrives the foundryman must combine experience with what little scientific data are at hand, and endeavor to aim at efficient feeding through these channels. To help in this, methods of feeding and gating should be carefully recorded for future reference.

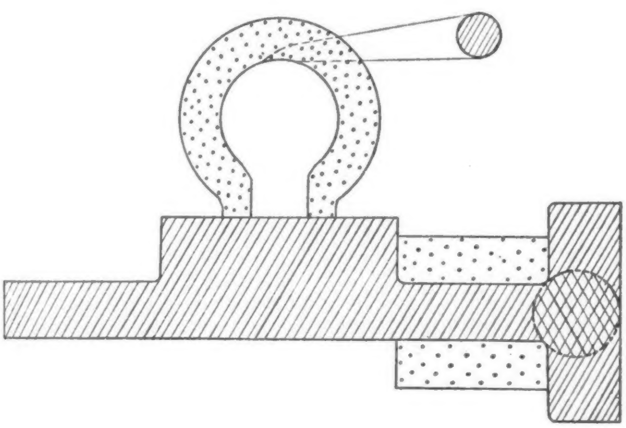


Fig. 11—A third example of exothermic application.

Conclusions

1. Crystalline growth has an important bearing on feeding efficiency. Variables such as solidification range, relative percentages of solids and liquids present in this solidification range, and the evolution of dissolved gas all control the degree of microporosity.

2. General principles of progressive freezing should be obeyed in order to obtain efficient feeding.

3. The flow of metal from a feeder head to the solidifying casting is a complex problem governed by factors such as fluidity, wall friction and head pressure.

4. Several factors governing feeding efficiency influence the feeder head capacity and the resultant shape of the cavity in the feeder head. Heavy rate of feed demands, and the maintenance of high fluidity all tend to give globular or flat-bottomed cavities.

5. Macroporosity can be overcome by using proper feeding technique, and the most economical method of obtaining this is by using pronounced directional solidification, e.g., by the use of insulating pads and/or exothermic padding or liquefiers. To overcome macroshrinkage, pressure higher than atmospheric would not appear to be necessary if relatively high fluidity in the head is maintained.

6. Where microshrinkage occurs, pressure heads combined with good feeding technique may eventually prove to be the best combination.

7. By the application of known scientific data it is possible within the next few years to reduce the present uncertain methods of feeding to a basis of mathematical precision, thus giving economical and efficient feeding methods.

APPENDIX

Calculation of Feeder Head Efficiency—Assume a casting to have 60 per cent maximum theoretical yield.

∴ Weight of casting = 60 units.

∴ Weight of heads = 40 units.

Net total amount of liquid shrinkage = 10 per cent.

∴ 10 units are required to compensate for liquid shrinkage.

The final casting will consist of 50 initial units and 10 units supplied by the feeder head.

The initial feeder head will consist of 40 units which finally remain in the frozen head and 10 units which flow from the head to the casting.

Hence 40 units of head metal are required to offset premature feeding in order that all 10 units flow to the casting.

$$\therefore \text{Feeder head efficiency} = \frac{10}{50} \times \frac{100}{1} = 20 \text{ per cent.}$$

The obvious method of raising feeder efficiency is to decrease the amount of liquid required in the feeder head to offset premature solidification.

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Acknowledgment

The author wishes to thank the directors of Catton & Co., Ltd., Yorkshire Steel Foundry and K. L. Steelfounders & Engineers, Ltd., for permission to publish this paper, although all opinions are not necessarily endorsed by these two companies.

EDITOR'S NOTE: Because of its timely interest and practical approach to casting feeding problems, this article is published in full in this issue. Certain theories of feeder head applications are advanced by the author, with the suggestion that further investigation may develop more efficient feeding methods and eliminate many of the present uncertainties.

FOUNDRY PERSONALITIES

William E. Butts, vice-president, General Metals Corp., San Francisco, and in charge of the Oakland Iron, Steel & Malleable Div., has been recently elected as president, Enterprise Engine & Foundry Co., San Francisco. In addition to actively retaining his position in General Metals' operations, Mr. Butts will also direct Enterprise's activities in the diesel engine, oil burner and food processing machinery fields.

Charles J. P. Hoehn, Sr., retired as president of the Enterprise Engine Company.

William E. Butts **J. G. Magrath**

J. G. Magrath has been selected by the Board of Directors, American Welding Society, to serve as the society's Executive Secretary. It was also announced that M. M. Kelly, secretary; W. Spraragen, Editor of the Welding Journal and Director of Welding Research Council; and S. A. Greenberg, Technical Secretary, will continue in their present capacities.

Mr. Magrath was born in Philadelphia. Holds memberships in ASM and Society of American Military Engineers as well as AWS. His previous connection before joining the society was with McAlear Mfg. Div., Climax Industries, Inc., as sales manager.

W. B. Peirce, president American Society of Tool Engineers, has resigned from the Flanery Bolt Co., Bridgeville, Pa., to devote more time to the activities of the society.

J. R. Cochran is now affiliated with J. I. Case Co., Rockford, Ill., as foreman. He was formerly metallurgist, Sundstrand Machine Tool Co., Rockford.

V. F. Stine, vice-president and sales manager, Pangborn Corp., Hagerstown, Md., recently announced changes of personnel in the Pittsburgh, Chicago and Pacific coast districts.

Ralph M. Trent, for 14 years manager of Pittsburgh and Central Pennsylvania, has been transferred to the Pacific Coast as manager of all Pangborn business on the West Coast.

John D. Wise, former director of purchases and district sales representative in Chicago, will succeed Mr. Trent as manager of the Pittsburgh district.

Frank Newell, having completed two years service in sales engineering and six years field work throughout the middle west, will be transferred to the Chicago office as district sales engineer.

Charles S. Sliter has been appointed assistant general sales manager, Kellogg Div., American Brake Shoe Co. Mr. Sliter was formerly sales promotional manager and has been with the company since 1940.

David A. Katcher has been appointed editor of a semi-popular magazine on physics which is to be published early next year. This announcement was made by Dr. Henry A. Barton, American Institute of Physics, New York City.

Mr. Katcher was formerly with the Naval Ordnance Laboratory, Washington, D.C., and prior to that time was in the Army. He graduated in physics from the University of Wisconsin, Madison, in 1936.

John H. Bruhn is now foundry superintendent, Eastern Malleable Iron Co., Wilmington, Del.

Thomas S. Wilmeth has been named assistant production control manager of Allis-Chalmers, general machinery, West Allis Works, according to an announcement by E. W. Bonness, works manager. He succeeds **R. L. Bruesewitz** who resigned. Recently, Mr. Wilmeth had been assistant superintendent of material control.

Frank Wartgow, who until recently was office manager, American Foundrymen's Association, has joined the sales group, foundry equipment division, Whiting Corp., Harvey, Ill. Prior to Mr. Wartgow's association with the A.F.A. he was with Hasbrouck Haynes Engineer's as a supervising engineer and the American Steel Foundries, manager of employee suggestion system.

Loren E. Boysel formerly associated with engineering and quality control for the Fisher Body Co., has been appointed body engineer at Willys-Overland Motors, according to Delmar C. Roos, vice-president in charge of engineering.

Dr. R. C. Mason has been named manager, electro-physics department, Westinghouse Research Laboratories, Pittsburgh, Pa., succeeding Gaylord W. Penney, who was recently appointed Westinghouse Professor of Electrical Engineering at the Carnegie Institute of Technology.

Selby F. Greer has been appointed general sales manager, Kellogg Div., American Brake Shoe Co., succeeding **H. O. Holland,** former sales manager. Mr. Greer, formerly assistant general sales manager, has served in various capacities since joining the Brake Shoe Company.

Morrough P. O'Brien, former dean of engineering, University of California, has joined the engineering staff of Air Reduction Co., Inc., New York City, according to a recent announcement by C. S. Munson, president of Air Reduction. Mr. O'Brien will be in charge of general and process engineering and will assume the direction of liquefaction research.

Dr. Floyd J. Metzger, vice-president in charge of liquefaction research, is resigning.

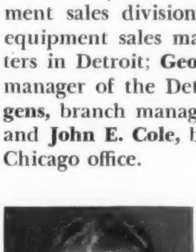
Harry E. Weiler is now manager, Louisville district sales office, Reynolds Metal Co., Louisville. During his association with Reynolds, Mr. Weiler has been assistant to the general product manager and was also product manager of the extrusion and tubing division.

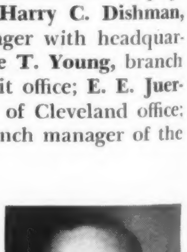
John W. Lohnes, district sales manager, Vanadium Corp. of America, for the past two years, has been named general sales manager, International Graphite & Electrode Corp., St. Marys, Pa. Mr. Lohnes had been associated with Vanadium for eleven years and prior to that time was connected with Carnegie-Illinois Steel Corp.

Frank A. Young, a representative in Allis-Chalmers Duluth, Minn., branch office since 1944, has been named manager of the office, according to an announcement by J. L. Singleton, vice-president, director of sales, general machinery division.

Bert Arant, formerly affiliated with the melting departments of Universal-Cyclops Steel Corp., has joined the Titanium Alloy Mfg. Co., Niagara Falls, N.Y., as development engineer. Mr. Arant will cover the western Pennsylvania and Ohio districts.

The following appointments were made in the Raybestos-Manhattan, Inc., equipment sales division: **Harry C. Dishman,** equipment sales manager with headquarters in Detroit; **George T. Young,** branch manager of the Detroit office; **E. E. Juergens,** branch manager of Cleveland office; and **John E. Cole,** branch manager of the Chicago office.





T. T. Alverson **F. E. Uhl**

Troy T. Alverson has been appointed assistant manager, dust and fume control division, American Wheelabrator & Equipment Corp., Mishawaka, Ind. Mr. Alverson was formerly a district sales representative for the company with offices in Baltimore, Md.

Fred E. Uhl has been appointed district sales representative, succeeding Mr. Alverson, with offices in Baltimore. Mr. Uhl was formerly sales engineer for Westinghouse Electric Co., New York City.

Ronald Tipping has joined the sales staff of Don Barnes Foundry Supplies & Equipment, Hamilton, Ont., Canada. He will cover territory from Hamilton to Kingston. Mr. Tipping was formerly associated with Otis Fensom Elevator Co. Ltd., as foundry superintendent.

Ronald Tipping **William Granat**

Rear **Admiral William Granat,** U. S. Navy (Retired) has joined the firm of Lester B. Knight & Associates, Inc., Chicago. In addition to his Naval professional experience, Mr. Granat has a well-rounded industrial background which began with postgraduate work in metallurgy at Lehigh University, Bethlehem, Pa. Later he spent four years at the U. S. Naval Gun Factory, Washington, D.C., as head of the metallurgical, metallographic, physical and chemical laboratories engaged in the research and development of ferrous and non-ferrous metals and various materials for ordnance use. There then followed many years in the Navy Department with the Bureau of Ordnance and the Secretary's Office which gave Admiral Granat a varied and broad experience through close contact with industry.

John W. Riches has been appointed engineering assistant, Metallurgical Engineers, Inc., Portland, Ore., it was announced by heads, Harry Czyzewski and David B. Charlton. Mr. Riches is a recent graduate of the State College of Washington and has done special research work in the field of heat treatment of aluminum alloys for the division of industrial research.

Aslak Kvalheim, director, Government Raw Materials Laboratory, Geological Museum, Oslo 45, Norway, was a recent visitor at A.F.A. headquarters. He has been in the United States almost a year on a Norwegian government scholarship. During most of the time he did spectrographic and metallurgical research.

E. J. Lindahl has resigned as associate professor, Ohio State University, Columbus, to accept the chairmanship of the department of mechanical engineering, University of Wyoming, Laramie. A graduate of the University of Wyoming, where he received his bachelor's degree in 1932 and his master's in 1933, Mr. Lindahl served as an instructor at Catholic University and at the University of Maryland before joining Ohio State in that capacity in 1939. He has served as editor-in-chief of "CTC News," published by the Columbus Technical Council. The council has named **E. L. Combs** of Battelle Memorial Institute, who has been managing editor, the new editor-in-chief.

T. H. Burke has resigned as metallurgist with Otis Elevator Co., Buffalo, to accept the position of chief metallurgist with the Teziutlan Copper Co., Mexico. The firm, originally engaged in mining, now operates a modern steel foundry. Mr. Burke, an A.F.A. member who has been with Western New York chapter, will join the Mexico City group.

Charles Stanton, field engineer with the Detroit office of Chain Belt Co., Milwaukee, has been transferred to the Philadelphia office in the same capacity.

R. A. Weinhardt has joined Willys-Overland Motors, Toledo, Ohio, as automotive plant engineer. A veteran of the automotive field who was concerned with the construction of high-powered engines for P.T. boats and aircraft during the war, he will be in charge of all engine design for the Willys-Overland firm.

C. P. West, Jr., who was associated for more than eight years with Campbell, Wyant & Cannon Foundry Co., Muskegon, Mich., has joined the W. G. Reichert Engineering Co. at Newark, N.J., as metallurgist and consulting engineer.

G. A. Vogt, for 41 years a furnace man with M. Greenberg's Sons, San Francisco, retired recently at 65. He was honored by the firm and fellow employees in a ceremony attended by other veterans of 15 years or more service with the firm. Participants included **S. N. Greenberg,** president and manager, 34 years; **Bert Raffo,** 30; **Harold Hendrickson,** 28; **George Delucchi** and **Jimmy Alberto,** 24; **Eino Pisila** and **Walter Norris,** 22; **Fred Diem, Emily Madden** (a secretary from the age of 15), **Carlos Olivas and Norman Barnett,** 21; **Renzo Giona** and **Bob Leitch,** 19; **Verner Hagberg, Ed Baer, Robert Nelson** and **E. J. Baker,** 15.

Employes receive a gold pin in the design of a fire hydrant (the famous "California type," produced by the firm), set with an emerald for 15 years, a diamond for 20.

Dr. George Sachs, professor of physical metallurgy at Case Institute of Technology, Cleveland, has been named director of the new research laboratory for physical metallurgy, there.

Armin Sonderegger, foundry engineer, George Fischer, Ltd., Schaffhausen, Switzerland, an A.F.A. member, was a recent visitor to the National Office. He is spending several months in this country to study American methods in foundries and other manufacturing plants. On his return to Schaffhausen, he will specialize in production techniques and controls.

Earl Beyerlein has left Schmutz Mfg. Co., Louisville, Ky., where he was assistant foundry superintendent, to join J. I. Case Co., Bettendorf, Iowa, as metallurgist.

A. G. Hovey was recently named head of the chemical division technical sales service, General Mills, Inc., Minneapolis. He has been with the firm three years as head of the research staff. A graduate of Dartmouth College, Hanover, N.H., Mr. Hovey has a background of 25 years in the field of synthetic resins.

R. B. Quinlan, section leader in the Schenectady works laboratory of General Electric Co., has been voted the annual Richard L. Templin award of the American Society for Testing Materials. He will be honored in recognition of his outstanding contributions to the field of testing methods and apparatus. Associated with General Electric since 1929, he has worked on fatigue problems for many years and is the developer of a pneumatic testing machine.

F. H. Gladhill, Jr., trades training apprentice at the East Pittsburgh plant of Westinghouse Electric Corp., has been awarded the George Westinghouse War Memorial Scholarship. He is the first trades apprentice to win the scholarship, which provides $2,000 to be applied toward an engineering course.

Georges Rosseau of Ghent, Belgium, was a recent visitor to the National Office. He operates his own brass foundry in Ghent, in production of valves and other plumbers' goods, and is in this country for a short time on firm business.

Desmond Gamble has been appointed sales representative, McNally Pittsburgh Foundries, Inc., Pittsburgh, Kans. He was formerly office manager for the firm.

Obituaries

Dr. William E. Wickenden, retiring president of Case Institute of Technology, Cleveland, died September 1 in Peterboro, N.H. He recently was selected to represent the Engineers Joint Council on the United States Commission for United Nations Educational, Scientific and Cultural Organization.

Donald J. Dalton, president, The Dalton Foundries, Inc., Warsaw, Ind., died on August 1.

Ray Sours, superintendent, aluminum foundry, Buffalo Pipe & Foundry Corp., Buffalo, N.Y., died September 9. Mr. Sours was formerly connected with Buick Motor Div., General Motors Corp., Flint and Monarch Aluminum Co., Cleveland.

Clinton R. Wyckoff, Atlas Steel Casting Co., Buffalo, N.Y., died August 16.

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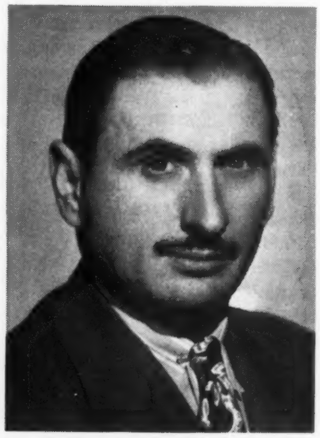

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Supplies & Equipment
Mexico, D. F.
Secretary
Mexico City Chapter

J. A. Shuffstall
National Erie Corp.
Erie, Pa.
Treasurer
Northwestern Pennsylvania Chapter

David Clark
Forest City Foundries Co.
Cleveland
Director
Northeastern Ohio Chapter

C. C. Sigerfoos
Michigan State College
E. Lansing, Mich.
Vice-Chairman
Central Michigan Chapter

W. R. Huffman
H. B. Salter Mfg. Co.
Marysville, Ohio
Treasurer
Central Ohio Chapter

P. R. Van Duyne
Meeker Foundry Co.
Newark, N.J.
Director
Metropolitan Chapter

★ NEW A.F.A. MEMBERS ★

August 15—September 15—Two Michigan and one Ohio group took top honors this month as for the first time in a number of months the new members total fell below 100. With only 20 chapters represented there are but 63 new applicants shown here. Central Michigan lists 8, Cincinnati District 6, and Western Michigan 4. Watch for your chapter next month, if not shown below, and see if it is growing.

CENTRAL MICHIGAN CHAPTER

James Bommarito, Finishing Foreman, Albion Malleable Iron Co., Albion.
Jesse J. Bommarito, Ass't Foreman, Albion Malleable Iron Co., Albion.
Fred Easton, Foundry Supt., Calhoun Foundry, Homer.
Dewey I. Doyle, Jr., Vice Pres., Doyle Vacuum Cleaner Div., Doyle Foundry Co., Grand Rapids.
Alex Passic, Engineer, Albion Malleable Iron Co., Albion.
Donald G. Sebolt, Finishing Foreman, Albion Malleable Iron Co., Albion.
Arthur J. Stone, Chemist, Albion Malleable Iron Co., Albion.
Arthur VanEmst, Ass't Foundry Supt., Fuller Manufacturing, Kalamazoo.

CHICAGO CHAPTER

Lyle Breecher, Partner, Standard Pattern Works, Chicago.
Kenneth S. Cowlin, Sales Engr., Electro Refractories & Alloys Corp., Buffalo, N.Y.

CINCINNATI DISTRICT CHAPTER

Jos. C. Eismann, Treasurer, The Dayton Oil Co., Dayton, Ohio.
Dixon Hunt, Director of Personnel, Bardes Forge & Foundry Co., Cincinnati.
Alfred Russell Mustard, Foreman Core Room, Bardes Forge & Foundry Co., Cincinnati, Ohio.
Lawrence W. Pathe, Production Control Supervisor, Bardes Forge & Foundry Co., Cincinnati, Ohio.
Robert E. Scherrer, Foreman, Cincinnati Milling Machine Co., Cincinnati.
William J. Schott, Time Study Man, Bardes Forge & Foundry Co., Cincinnati, Ohio.

DETROIT CHAPTER

Price B. Burgess, Dept. of Met. Proc., University of Michigan, Ann Arbor, Mich.
Dick Shepherd, Field Engineer, Peninsular Grinding Wheel Co., Detroit.
Leo W. Wickson, Director, Universal Engineering Co., Frankenmuth, Mich.

EASTERN CANADA AND NEWFOUNDLAND CHAPTER

Paul Biron, Manager, La Fonderie de Ste. Croix Ltee, Ste. Croix, Que.
Emile Jodry, Manager, Montreal Foundry Ltd., Montreal, Que.
Wm. G. Sharkey, Chief Inspector, Robert Mitchell Co. Ltd., St. Laurent, Que.

METROPOLITAN CHAPTER

Eugene Wm. Matte, Apprentice Foundryman, Barnett Foundry & Machine Co., Irvington, N.J.

MEXICO CITY CHAPTER

Enrique Alquisira M., Ing. Mec. Fundiciones de Hierro y Acero, S.A., Mexico, D.F.
Benito Galarraga, Mechanical Engr., Manufacturas Metalicas, Mexico, D.F.
Isidro Lopez Llorente, Mexico, D.F.

MICHIANA CHAPTER

*Bridgman Castings, Inc., Bridgman, Mich. (Harry E. Davies, Vice Pres. & Gen. Mgr.)
Everett Mabry, Molding Dept. Foreman, Bridgman Castings, Inc., Bridgman, Mich.

NORTHERN CALIFORNIA CHAPTER

Jack F. Mainzer, V. P., Pacific Brass Foundry of San Francisco, San Francisco.

NORTHEASTERN OHIO CHAPTER

Jack Kroecker, Supt. Sand Foundry, Aluminum Co. of America, Cleveland.

ONTARIO CHAPTER

Walter Lapsley, Chief Inspector, Massey Harris Co. Ltd., "M" Foundry, Brantford.
*Massey Harris Co. Ltd., Brantford, (Herbert K. Matthews, Works Mgr. "M" Foundry).

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* Company Member

ROCHESTER CHAPTER

Harry Hanna, The Anstice Co., Inc., Rochester, N.Y.
Bertram E. Oberlin, The Anstice Co., Inc., Rochester, N.Y.

SAGINAW VALLEY CHAPTER

Bruce J. Allen, Student, Buick Motor Div., General Motors Corp., Flint, Mich.
Donald K. Steiner, Student, Central Foundry Div., General Motors Corp., Saginaw, Mich.

ST. LOUIS DISTRICT CHAPTER

W. B. Smith, Branch Manager, Independent Pneumatic Tool Co., St. Louis.

SOUTHERN CALIFORNIA CHAPTER

Everett V. Angell, Sec'y., Red Seal Metals Co., South Gate.
Robert C. Coulson, Fdry. Supt., Kaiser Co., Inc., Iron & Steel Div., Fontana.

TIMBERLINE CHAPTER

B. P. Naiman, Resident Inspector, Griffin Wheel Co., Denver, Colo.

TWIN CITY CHAPTER

Paul R. Hennum, Foundry Tech., American Hoist & Derrick Co., St. Paul, Minn.
Earl F. Rossman, H. & R. Pattern Co., Minneapolis, Minn.

TOLEDO CHAPTER

Floyd R. Brown, Assistant Sales Mgr., Unitcast Corp., Toledo, Ohio.
R. C. Van Hellen, Production Mgr., Unitcast Corp., Toledo, Ohio.

WASHINGTON CHAPTER

Wm. T. Orr, Salesman, Marwood Ltd., Seattle.

WESTERN MICHIGAN CHAPTER

Kenneth E. Conklin, Pattern Supervisor, Michigan Wheel Co., Grand Rapids.
Valerian A. Lenar, Metallographer, Campbell, Wyant & Cannon Foundry Co., Muskegon.
Gordon Robidoux, Fdry. Supt., Lakey Foundry & Machine Co., Muskegon.
Lyman L. Steiner, Ass't. Supt. Pattern Shop, Lakey Foundry & Machine Co., Muskegon.

WESTERN NEW YORK

*Geo. A. Knowles Foundry, Inc., Niagara Falls, (Geo. A. Knowles)

OUTSIDE OF CHAPTER

P. T. Campbell, Treasurer, Harrison-Corry Co., Knoxville, Tenn.
E. N. Harrison, President, Harrison-Corry Co., Knoxville, Tenn.
Colonel William L. Longley, USA, Retired, Director, Dunbarton Casting Laboratory, Dunbarton, N.H.
Ralph L. Rogers, Jr., Vice President, Harrison-Corry Co., Knoxville, Tenn.

Brazil

William D. Rader, Supt. of Melting, Companhia Brasileira de Material. Ferroviario (Brasilian Railroad Equipment Co.) Sao Paulo.

Cuba

Luis A. Lombana, Plant Engineer, Fundicion Cruces, S.A. Las Villas.

Chile

Ernesto Ayala, General Manager, Fca de Enlozados, S.A., Santiago.

Czechoslovakia

Jng. Vaclav Oliverius, Plant Manager, Jawa-Foundry Zbrojovka Brno, N.P.-Tynec-Nad-Sazavou.
Adolf Plesinger, D.S. Director in Charge of Fdry. Div., Metal & Engr. Wks. Nat. Corp., Praha.
Vitkovicke Zelezany, Vitkovicke Zelezarny Zau, Knih. Ostrava.

New Zealand

William Brian Dunn, Technical Engr., Wm. Cable Co., Kaiwarra.

Norway

Aslak Kvalheim, Government Raw Materials Laboratory, Oslo.

★ CHAPTER ACTIVITIES ★

news

Central Ohio

H. W. Lownie, Jr.
Battelle Memorial Institute
Chapter Reporter

FROM 2-7 PM the program of the Central Ohio chapter's third annual outing was filled with a variety of sports and games. The 200 members and guests who congregated at the Columbus Riding Club, Columbus, Ohio, on August 9 found little time on their hands when there was baseball, horeshoe pitching, dart throwing or story swapping to chose from.

At dinner a number of prizes were awarded and the traditional floor show was on tap.

Success of the outing was due to the hard work of the sixteen man committee headed by J. Gray Lummis, A. P. Green Fire Brick Co., Columbus, and to the newly elected Central Ohio officers including Chairman Ray Frank, Bonney-Floyd Co., Columbus; Vice-Chairman Fred Fuller, National Engineering Co., Columbus; Secretary D. E. Krause, Battelle Memorial Institute, Columbus; and Treasurer Bill Huffman, H. B. Salter Mfg. Co., Marysville, Ohio.

St. Louis District

Paul C. Schwarz
National Bearing Div.
Publicity Chairman

SEVERAL HUNDRED chapter members and their friends enjoyed the annual picnic of the St. Louis District chapter. A day devoted to playing ball, cards and eating barbecued ribs was hard for the local men to overlook, for most it was a must.

Despite hot weather and a change in the meeting date, a large crowd turned out for the first fall meeting of the chapter. The mass hypnotism demonstration was quite fascinating and Clyde R. Powell, Endicott Johnson Corp., Endicott, N.Y., made quite a hit with his "Understanding and Controlling Human Behavior."

Southern California

Ralph N. Schaper
Westlectric Castings, Inc.
Chapter Reporter

SOUTHERN CALIFORNIA chapter's tenth annual summer outing was

A picture taken while Clyde R. Powell, Endicott Johnson Corp., Endicott, N.Y., was attempting to demonstrate mass hypnotism. Mr. Powell was guest speaker at the first fall meeting of the St. Louis District chapter.

Over 350 foundrymen attended the Southern California chapter's Tenth Annual Summer Outing at the Lakewood Country Club, Long Beach, in August. The day's program included shop talk, baseball, golf and singing; and despite the bored expressions on the faces of the "shutter bugs" (bottom, right) everybody had a grand time.

CHAPTER MEETINGS
OCTOBER-NOVEMBER

OCTOBER 16

DETROIT
Rackham Memorial
ROUND TABLE MEETINGS

OCTOBER 17

TEXAS
San Antonio

BIRMINGHAM DISTRICT
Tutwiler Hotel
THOMAS W. CURRY
Lynchburg Foundry Co.
Chemically Treated Molding Sand

NORTHERN CALIFORNIA
Orinda Country Club
GOLF TOURNAMENT

OCTOBER 20

QUAD CITY
Ft. Armstrong Hotel, Rock Island, Ill.
LADD SALACH
Plastic Corporation of Chicago
Plastic Patterns

SOUTHERN CALIFORNIA
Rodger Young Auditorium, Los Angeles
LESTER B. KNIGHT
Lester B. Knight & Associates
Foundry Modernization
NATIONAL OFFICERS NIGHT

OCTOBER 22

TOLEDO
Yacht Club, Toledo

OCTOBER 24

CHESAPEAKE
Engineers Club, Baltimore, Md.
J. A. BOWERS
American Cast Iron Pipe Co.
Foundry Coke

OCTOBER 27

CENTRAL OHIO
Chittenden Hotel, Columbus
L. W. DEAN
The Dean Company
Precision Castings

NORTHWESTERN PENNSYLVANIA
Moose Club, Erie, Pa.
NATIONAL OFFICERS NIGHT

OCTOBER 28

TIMBERLINE
Oxford Hotel, Denver, Colo.
FRANK STEINEBACH
The Foundry

CENTRAL MICHIGAN
Parker Inn Hotel, Albion
E. KING
Hill & Griffith Co.
Stabilizing Foundry and Core Sands

OCTOBER 31

ONTARIO
Royal York Hotel, Toronto
ROUND TABLE DISCUSSIONS

NOVEMBER 3

CENTRAL INDIANA
Athenaeum Hotel, Indianapolis
QUESTION AND ANSWER PANEL

CENTRAL ILLINOIS
Jefferson Hotel, Peoria, Ill.
G. P. HALLIWELL
H. Kramer & Co.
Non-Ferrous Foundry Practice

CHICAGO
Chicago Bar Association
THOMAS W. CURRY
Lynchburg Foundry Co.
Chemically Treated Molding Sands
NATIONAL OFFICERS NIGHT

METROPOLITAN
Essex House, Newark, N. J.
F. W. HANSON
Electro Metallurgical Co.
Production of Iron for Quality Castings

NOVEMBER 4

MICHIANA
LaSalle Hotel, So. Bend, Ind.
MAX KUNIANSKY
Lynchburg Foundry Co.
NATIONAL OFFICERS NIGHT

NOVEMBER 6

SAGINAW VALLEY
Fischer Hotel, Frankenmuth, Mich.
RICHARD A. FLINN
American Brake Shoe Co.
Engineering & Casting

NOVEMBER 10

CINCINNATI DISTRICT
Engineering Society Headquarters
V. J. SEDLON
Master Pattern Co.
Patternmaking

NOVEMBER 11

NORTHERN ILLINOIS & SOUTHERN WISCONSIN
Hotel Hilton, Beloit, Wis.
NATIONAL OFFICERS NIGHT

ROCHESTER
Seneca Hotel
J. A. GITZEN
Delta Oil Products Co.
Core Room Practice

NOVEMBER 13

NORTHEASTERN OHIO
Cleveland Club

CANTON DISTRICT
Elks Club, Alliance, Ohio
ROUND TABLE DISCUSSIONS

NOVEMBER 14

E. CANADA & NEWFOUNDLAND
Mount Royal Hotel, Montreal
J. S. VANICK
International Nickel Co.
Nickel Alloys

NORTHWESTERN PENNSYLVANIA
Dunkirk, N.Y.

NOVEMBER 19

TOLEDO
Yacht Club, Toledo

NOVEMBER 20

TWIN CITY
Covered Wagon, Minneapolis
G. VENNERHOLM
Ford Motor Co.
Casting Methods in Automotive Engineers

NOVEMBER 21

OREGON
Hyster Co.
PLANT VISITATION

held August 9 at the Lakewood Country Club, Long Beach. More than 350 were present at this affair.

Pete Valentine, Del Monte Properties Co., San Francisco, and his musicians made the trip down and did a fine job of entertaining the men with familiar songs.

Golfing and a baseball game, which ended in a 20-20 tie score, were the activities of the day.

Ontario

R. C. Tiplady
Westman Publications Ltd.
Chapter Reporter

THE WM. R. BARNES estate, "Barnesdale," was once again the site for the Ontario chapter's annual picnic and golf tournament which was held August 23.

Rifle shooting, darts, horseshoe pitching, golf and many other attractions provided a fund of entertainment for everyone.

No. Illinois-So. Wisconsin

C. L. Dahlquist
Greenlee Bros. & Co.
Chapter Tech. Secretary

FOUNDRY CORE blowing held the limelight when 85 foundrymen gathered at the September 9 meeting of the Northern Illinois-Southern Wisconsin chapter. The members met at the Hotel Faust, Rockford, Ill., to hear an interesting and informative talk given by Zigmond Madacey, foundry superintendent, Caterpillar Tractor Co., Peoria, Ill.

With the aid of slides, Mr. Madacey was able to show the wide range of corework and coreboxes that can be handled by coreblowers. Core-blow boxes were shown to illustrate the positioning of venting and blow-holes.

Mr. Madacey explained that in blowing cores the size of the blow holes are determined by the size of the void to be filled with sand, and vents should be plentiful but not used in excess. After considerable experience it was found that vents and blow holes could be anticipated and included in blue prints of core boxes. There can be no set standard ratio of vents to blowholes, because the path of flow of the sand varies according to the contour of boxes or patterns.

It was indicated that moisture of the sand mix should be the proper ratio to sand so that both sand and water move through the blow holes in the same volume. For small blowers the sand should be tempered to 1.8 per cent moisture and up to 2.5

Below—Past Chapter Chairman Jock Witherspoon (seated), Bibby Foundry, Galt, takes in the money at the Ontario chapter picnic and in return hands tickets to (starting left) J. White and R. Shantz, P. E. Shantz Foundry, Preston; and A. E. Bock, Production Castings Ltd., New Toronto. Right—Oil up the shootin' iron, maw, thar's target practice today. Bottom—A firm grip and swift arm sends the dart to the bulleseye. These photographs were taken at "Barnesdale," the Wm. R. Barnes, estate.

Left to right (standing)—Central Michigan Chapter Directors John E. Wolf, Midwest Foundry Co., Coldwater, Mich., and Erwin Doerschler, U. S. Foundry Co., Kalamazoo, Mich.; Lou Dobson, Albion Malleable Iron Co., Albion, Mich.; and Chapter Chairman Douglas Strong, Foundry Materials Co., Coldwater, congratulate Chapter Secretary-Treasurer Fitz Coghlin, Jr., Albion Malleable Iron Co., (seated) for the fine ticket selling job he did at the chapter outing. This all day affair was held at the Water Works Park, Coldwater.

per cent moisture on large core blowers. The smaller the aperture, that the sand is blown through, the less moisture is required. Sand that is too dry cuts into the core boxes considerably. Sand that is too wet blows into the box all right but water is blown through first causing core sand to stick to the box.

Central Michigan

C. C. Sigerfoos
Michigan State College
Chapter Reporter

All of the 200 foundrymen who attended the Central Michigan chapter's picnic went home with the feeling that the outing chairman Edward H. Schlepp, Riverside Foundry & Galvanizing Co., Kalamazoo, had done a fine job. Activities were confined to Water Works Park, Coldwater, Mich., on August 16.

Of the various scheduled sporting events, softball and horseshoe pitching attracted the largest number of players. Excitement during the day reached its peak when a team from the Albion Malleable Iron Co. challenged any team at the picnic. The challenge was soon snapped up by a team made up of players from various Central Michigan foundries. However, it was to no avail as the "scrubs" dropped an 8-2 contest to the Albion outfit.

Master of ceremonies for the evening's entertainment was Chapter Chairman Douglas J. Strong, Foundry Materials Co., Coldwater, Mich.

Mexico City

N. S. Covacevich
Casa Covacevich
Chapter Secretary

A film on the jolt rock-over pattern draw molding machine was viewed by the 90 men attending this meeting. Following the movie, a discussion period followed.

The doors of the Mexico City chapter are always open and all visiting A.F.A. members are welcome, so states Mr. Covacevich.

Rochester

Leon C. Kimpal
Rochester Gas & Electric Corp.
Secretary-Treasurer

The fourth annual outing of the Rochester chapter was held at Elser's Grove with an attendance of about 200. The chapter welcomed a contingent from Buffalo and gave them a royal welcome.

The day was spent in talking shop while the younger set engaged in

Past Presidents of the Southern California chapter who were present at the June meeting are (left to right): Robert Gregg, Reliance Regulator Corp., (1937-38), A. G. Zima, International Nickel Co., (1939-40), J. E. Eppley, Kinney Iron Works, (1940-41), B. G. Emmett, Los Angeles Steel Casting Co., (1941-42), Earl Anderson, Enterprise Iron Works, (1942-43), W. F. Haggman, Foundry Specialties Co., (1943-44), W. D. Bailey, Jr., Westlectric Castings, Inc., (1944-45), R. R. Haley, Advance Aluminum & Brass Co., (1945-46), and W. D. Emmett, Los Angeles Steel Casting Co., (1946-47).

the sports program which was scheduled.

In the evening a barbecue dinner was served and was extremely tasty. Prizes for the lucky winners were handed out following the meal.

Northwestern Pennsylvania

Earl M. Strick
Erie Malleable Iron Co.
Chapter Reporter

FEATURE EVENT of the Northwestern Pennsylvania chapter's second annual picnic and golf tournament was the wresting match between Chapter Chairman J. W. Clarke, General Electric Co., Erie and Fritz Diemert, Erie Casting Co., Erie. It was officially called a draw after 15 minutes of groaning and grunting. Time and place where the mighty clash occurred was the Lake Shore

The Northwestern Pennsylvania chapter picnic and golf tournament supplied all concerned with a day's entertainment. Top — An orange necking contestant attempting to keep his orange under control. Center—Start of the egg tossing contest. Bottom—Chapter Chairman John W. Clark, General Electric Co., Erie (with balloon) before the balloon busting contest began.

Ticket takers at the St. Louis District chapter summer picnic are (starting left) Webb L. Kammerer, Midvale Mining & Mfg. Co., St. Louis; Oscar Lanier, Duncan Foundry & Machine Co., Alton, Ill.; A. S. Hard, St. Louis Steel Casting Co., St. Louis; George Shepherd, Duncan Foundry & Machine Co.; Walter Zeis, Walter Zeis Foundry & Equipment Co., Webster Groves. Several hundred had an enjoyable time, which included a ball game and a meal of barbecued-ribs.

Country Club and Ranchers Grove, August 23.

Approximately 200 attended the all day festivities that started with golf matches in the morning, a buffet lunch at noon and a dinner in the evening with the usual refreshments and games in-between.

Chairman was James Farina, American Sterilizer Co., Erie and his committee included: Frank Volgstadt, Griswold Mfg. Co., Erie; Wm. Bartels, Erie Malleable Iron Co.; Courtney Wilcox, Cascade Foundry Co., Erie; Bailey Harrington, Hickman, Williams & Co., Erie; and Fred Carlson, Weil-McLain Co., Erie.

Canton District

C. F. Bunting
The Pitcairn Co.
Chapter Chairman

THE UNIQUE experience of riding from the gates of the Otis Clay farm to the picnic grounds in a hack drawn by a team of mules, greeted the 175 who came to the Canton District chapter picnic on August 23. Situated five miles north of Massillon, the farm site afforded ample opportunity for foundrymen to exercise their muscles playing baseball, horseshoes, volleyball, horseback riding and numerous other sports.

Following the days workout, the men were treated to a real country dinner and then sat back and relaxed as the prizes were awarded and a floor show was put on.

Northeastern Ohio

W. G. Gude
Penton Publishing Co.
Chapter Reporter

G. VENNERHOLM, assistant head of research in Ford Motor Co.'s chemical and metallurgical department, was the principal technical speaker at the opening fall meeting of the Northeastern Ohio chapter. Held at the Cleveland Club, September 11, the meeting attracted approximately 250 members and guests. An added feature was a complete clambake dinner preceding the meeting.

James H. Lansing, consulting engineer, Malleable Founder's Society, Cleveland gave the coffee talk, discussing the activities of his organization and describing the metallurgical developments which have occurred in malleable castings since the early days of the industry.

Howard C. Gollmar, Elyria Foundry Div., Industrial Brownhoist Corp., Elyria, Chapter President, presided at the meeting, with Elmer C. Zirzow, National Malleable & Steel Castings Co., Cleveland, Chapter Vice-President, in charge of the technical portion of the program.

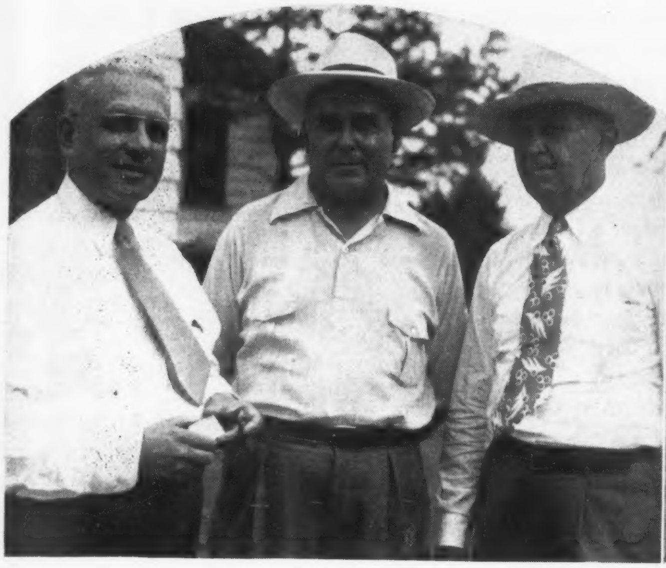
Mr. Vennerholm spoke on "Casting Methods in Automotive Manufacture" and by the use of slides gave an exceptionally interesting portrayal of the variety of casting applications and foundry methods employed in motor car building. Casting practices, as followed by the Ford company and discussed by the speaker, included die casting, centrifugal casting, investment mold casting, and plaster molding, in addition to the commoner types of ferrous and non-ferrous casting production. In a number of instances castings have supplanted parts made previously by other fabricating methods.

Wisconsin

John Bing
A. P. Green Fire Brick Co.
Chapter Reporter

SOMEWHAT OF an attendance record was established at the Septemper 12 meeting of the Wisconsin chapter when 312 foundrymen put in an appearance. As usual the dinner meeting and sectional sessions were held at the Schroeder Hotel, Milwaukee.

The gray iron, technical and malleable men held a joint meeting which attracted 168. The subject was chemically treated sand and the






John Bing, A. P. Green Fire Brick Co., Milwaukee, caught the holiday spirit on the above faces of both golfers and non-golfers as they played "hooky" from their shops for a day of fun at the Ozaukee Country Club, Milwaukee. This spot was the scene for the Wisconsin chapter's annual outing and golf party and upon which the weatherman was kind enough not to drop any liquid sunshine. The day was enjoyed by all.

speaker was George P. Antonic, Walter Gerlinger, Inc., Milwaukee.

W. F. Sherman, International Harvester Co., Chicago, explained to 64 interested persons "Supervision's Place in a Grievance Procedure."

"How Should I Use an Aluminum Casting" by W. C. Shirley, chief metallurgist, U. S. Reduction Co., East Chicago, Ind., was the nonferrous group's topic.

The pattern group met and heard Steve Denkinger, Atlas Pattern Works, Butler, Wis., discuss "Advancement and Plastic Pattern Technique."

Birmingham District

J. P. McClendon
Stockham Pipe Fittings Co.
Publicity Chairman

A STIRRING BATTLE between the softball teams of Ike Young and "Four Ball" Jones highlighted the fourteenth annual outing of the Birmingham District chapter held September 20. Young was acting captain of the Stockham Terrors while Jones was leader of the Acipco Tornados. Harry G. Mouat, Whiting Corp., Birmingham, and R. R. Deas, Birmingham umpired the game that featured pulled muscles, sprained ankles, good hitting and fine fielding.

The hot match was cooled off when a number of the participants ended up in the pool of the Roebuck Country Club.

Horeshoe pitching and golf filled in the dull spots for those not participating in the ball game or swimming.

Chairman of the outing was D. C. McMahen, Harbison-Walker Refractories Co., Birmingham. The ticket distribution was accomplished by Herman Mattison, DeBardeleben Coal Corp., Birmingham, and Guy Bagley, Woodward Iron Co., Birmingham and their efforts were not in vain as between 500 and 600 foundrymen put in an enjoyable day. The athletic program was lined up by Gene Whelchel, American Cast Iron Pipe Co., Birmingham and Morris Hawkins, Stockham Pipe Fittings Co., Birmingham.

The day was topped off with an appetizing barbecued dinner.

Central New York

John A. Feola
Crouse-Hinds Co.
Publicity Chairman

AN OUTING AND dinner at the Cold Springs Inn, Syracuse, N.Y., September 12, designed for the purpose of promoting good fellowship and making acquaintances, was a big success. This opening meeting of the 1947-48 chapter year brought out 90 members and guests. Nothing in the way of business or technical sessions were conducted but before the evening was over a good many molds were made and heats run off.

Roy Miller and E. Doerschler, U. S. Foundry Corp., Kalamazoo; H. O. McCool, American-Marsh Pumps, Inc., Battle Creek; W. B. Miller, Battle Creek Foundry Co., Battle Creek; and John Granger, Calhoun Foundry Co., Inc., Homer, attended the May meeting of the Central Michigan chapter to hear C. B. Schureman, Baroid Sales Div., National Lead Co., Joliet, Ill.

Sells 'em and Tells 'em

Have you ever had the honor of selling tickets at an A.F.A. meeting at which you were the principal speaker? Very few A.F.A. members can answer that question in the affirmative. One person who recently successfully completed this stunt was L. C. Kimpal, Rochester Gas & Electric Corp., and Rochester chapter's secretary-treasurer. The story goes as follows:

Peter Blackwood, Ford Motor Co., Windsor, Ont., Canada, was the scheduled March 11 speaker for the chapter but, due to illness could not be present. John Perkins, of the same firm, notified the chapter he would substitute for Mr. Blackwood. On March 6 Mr. Perkins informed the chapter he would not be able to fill the date as expected. H. P. Gray, Gray Mfg. Co., Syracuse was approached and he gladly accepted. The evening of the meeting a telephone call informed the chapter officers that Mr. Gray had suddenly been hospitalized. The chapter vice-president Larry Gleason, Gleason Works, called on Mr. Kimpal who responded with a talk on "Gas Manufacture and Industrial Gas Utilization." Consequently as treasurer, he had the distinction of selling dinner tickets for himself as principal speaker.

Foundry Dust Control Symposium Available

THE A.F.A. publication, SYMPOSIUM ON FOUNDRY DUST CONTROL, consisting of 24 pages of vital technical information on foundry dust collecting equipment and systems is available to the foundry engineer, manager or superintendent. This symposium should help management in making the foundry more efficient and economical to operate and a better place in which to work.

The symposium consists of six technical papers presented at a joint meeting of the A.F.A. Plant Equipment and Safety and Hygiene Committees during the 1946 Cleveland convention on the following subjects: hoods and piping for foundry dust control systems; centrifugal dust collectors; cloth type dust collectors; wet type dust collectors; fans, and exhausters, and mainte-

nance of foundry dust control equipment.

It is profusely illustrated and 8¼ x 11¼ inches in size with a gray paper cover. Available to members of A.F.A. at $1.00 per copy; to non-members $2.50 per copy.

The A.F.A. Committee sponsoring this Symposium consisted of Jim Thomson, *Chairman*, Chief Works Engineer, Continental Foundry & Machine Co., East Chicago, Ind., H. B. Nye, *Vice-Chairman*, General Superintendent, New York Air Brake Co., Watertown, N. Y., E. W. Beach, Engineering Executive, Campbell, Wyant and Cannon Foundry Co., Muskegon, Mich., and W. R. Jennings, Foundry Superintendent, John Deere Tractor Co., Waterloo, Iowa.

TOOL ENGINEERS HEAR EAGAN AT JOINT AFA-ASTE MEETING

DURING THE Machine Tool Builders Show held in Chicago, a number of cooperating technical societies held joint evening sessions pertaining to timely and important industrial processes and developments. One of the most interesting, and one that attracted wide-spread interest, was the joint A.F.A.-ASTE meeting on Friday evening, September 19, at the Hotel Sherman. Two well-qualified speakers addressed the meeting over which F. J. Schmitt, director of sales, D. A. Stuart Oil Co., Ltd., Chicago, presided. Co-chairman was S. C. Massari, A.F.A. Technical Director.

Speakers for this joint session were: M. S. Curtis, assistant director of engineering, Warner & Swasey Co., Cleveland and T. E. Eagan, chief metallurgist, Cooper-Bessemer Corp., Grove City, Pa. Mr. Curtis spoke on "Turning Points in the Metalworking Industry" and Mr. Eagan had as his topic "When and How to Use Cast Iron."

Political Problems

Curtis discussed the political and commercial problems which have developed from the war and pointed out the need for accepting sensational wartime developments in machining with reservation.

He said that a desolate, unproductive Europe was receptive to radical ideologies, but that under a balanced economy this would not be true. Pointing out that a healthy Europe is necessary to a healthy U.S.A. and that both are required to prevent another world war, he stressed the need for production.

There are two ways to increase production, he said: (1) increase the output of direct labor, (2) development of more efficient machining operations. There is little prospect of the former, Mr. Curtis said, because initiative has been killed by a paternalistic government.

In discussing more efficient machining operations, he explained that the high rotational speeds, heavy feeds and new equipment developed during the war were for highly specialized operations. The same practice cannot be carried over into peacetime production.

Industry Uses Cast Iron

He illustrated the need for controlled enthusiasm for new developments by reviewing the attempts of welding enthusiasts who tried to get machine tool manufacturers to convert 100 per cent welded designs. Most builders tried welding but reverted to cast iron which still holds the field. The uncontrolled enthusiasm had a deleterious effect on welding in the machine tool industry.

Minor increases in efficiency can be made through faster machining operations but the greatest improvements can be made through reduction in handling times.

A good portion of Mr. Eagan's talk was devoted to the physical properties of cast iron so as to acquaint the tool engineers with the when and how to use cast irons. A number of times he referred to the A.F.A. publication, CAST METALS HANDBOOK, and he advised everyone to read it. It is a valuable publication due to the information it possesses, Mr. Eagan stated.

Starting with tensile strength, the speaker went on to cover yield point; compression strength, modulus of elasticity; endurance limit; notch sensitivity; damping capacity; impact and brittleness; castability; machinability; wear, corrosion and heat resistance; chemical analysis and heat treatment.

Mr. Eagan said the principles of good casting design are the same for steel, cast iron or the non-ferrous metals. In general, he said, the things to avoid may be briefly covered by stating that the sections of the castings should be as uniform in thickness as possible; ample fillets should be allowed in corners. The casting should be so designed that it can be divided into two halves without having an irregular parting line; the design should be such that the casting will solidify properly; and from the economical point of view it should require the simplest possible core set-up.

In conclusion it was pointed out that castings can always be designed so that they can be made—consult your foundryman.

Return Request Forms For Bound Volume

THE PUBLISHING of the 1947 Bound Volume of TRANSACTIONS of the American Foundrymen's Association, carrying the papers, committee reports and discussions presented at the 1946 Golden Jubilee Convention held in Cleveland, is now near completion. Order requests have been sent out to all members and if members have not filled their request forms out, the Association urges them to do so immediately and return them to the National Office, 222 West Adams St., Chicago 6. Distribution of the book will be made in the near future. The 1947 TRANSACTIONS will be published as a limited edition, based upon pre-publication requests from the membership.

Copies Gratis

Effective with the publication of this book, all paid-up company and sustaining members on record as of the date of publication will receive one cloth bound copy of the 1947 TRANSACTIONS gratis on request. Similarly, all personal members will receive a paper-bound copy gratis on request. Cloth bound copies will be available to all members at $2.00 per copy; non-members $15.00.

★ OCTOBER WHO'S WHO ★


E. E. McSweeney

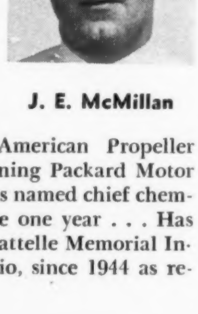
E. E. McSweeney received his Ph.D. from the University of Rochester, Rochester, N.Y. in 1938 . . . Had previously attended Oberlin College, Oberlin, Ohio, (1934) and obtained his Bachelor of Arts . . . A staff member of Battelle Memorial Institute, Columbus, Ohio, since 1938, Mr. McSweeney is supervisor in plastics and rubber research . . . Prior to assuming this position he was a research associate in 1938, research engineer in 1939, and assistant research supervisor in 1943 . . . Co-author of articles appearing in *Rubber Age, Plastics Catalog* (1945) and *Modern Plastics Encyclopedia* (1946) . . . Collaborated with J. E. McMillan and has written a paper on resin bonded core sands.


C. W. Briggs

C. W. Briggs, recipient of the Wm. H. McFadden Medal of the American Foundrymen's Association, was graduated from Stanford University, Calif., in 1926 and was awarded the degree of engineer in 1928 . . . He served as a miner, underground for Phelps Dodge Mining Co., Bisbee Ariz., and later was made laboratory assistant in metallurgy at Stanford University . . . His entry into the research field was with the Standard Oil Co. Richmond, Calif. in 1928 . . . The following year he was placed in charge of metallurgical research for Pacatome Ltd., San Francisco, a position from which he resigned to enter the U. S. Naval Research Laboratory, Anacostia, Washington, D.C., in 1930 . . . He was advanced to assistant physicist and in 1935 was appointed physical metallurgist in charge of the steel castings section foundry and research consultant to the Navy department on steel castings and gamma ray radiography . . . Is now affiliated with Steel Founders Society of America as technical and research director . . . His findings have been published widely by the trade press and he is a frequent speaker at meetings of technical societies . . . Member of American Institute of Mechanical Engineers, American Society for Metals, American Society of Naval Engineers and American Foundrymen's Association.


G. E. Dalbey

Metallurgist, Mare Island Naval Shipyard, Mare Island, Calif., is the title and affiliation of G. E. Dalbey . . . Contributes an article on segregation in manganese bronze . . . Is not new to readers of AMERICAN FOUNDRYMAN as his paper on gas elimination was published in September, 1946 . . . The author attended the University of Kansas City, Kansas City, Mo., and majored in chemistry . . . Later took a course in physical chemistry and metallurgy at University of California, Berkeley . . . In 1910 he joined American Smelting & Refining Co., Omaha, Neb., as research chemist and metallurgist . . . Eight years later (1918) became associated with Eastern Brass & Ingot Corp., Waterbury, Conn., as chief chemist and metallurgical superintendent . . . Received a temporary appointment as curator, Department of Chemistry, University of California, Berkeley in 1930 . . . Affiliated with Abbot A. Hanks, Inc., San Francisco, in 1932 he was named chemist and metallurgist . . . Also from 1934-41 was instructor of metallurgy, Adult Division, San Francisco Public Schools . . . Was appointed metallurgist, Mare Island Naval Shipyard in 1941.


J. E. McMillan

A native from the Buckeye state, J. E. McMillan is a graduate of DeSales College with a Bachelor of Science degree . . . Began his industrial career with Interlake Iron Corp., Toledo, Ohio, as a chemist and left that organization in 1942 . . . From 1942-43 was chemist at American Propeller Corp., Toledo . . . Joining Packard Motor Car Co., Toledo, he was named chief chemist and remained there one year . . . Has been associated with Battelle Memorial Institute, Columbus, Ohio, since 1944 as research chemist . . . Co-author with E. E. McSweeney, of paper herein dealing with resin bonded core sands . . . Is a member of American Chemical Society and American Electroplater's Society.


S. L. Finch

North American foundrymen who have had the opportunity of reading recent issues of *Foundry Trade Journal* will undoubtedly remember the name of S. L. Finch in connection, with a number of papers on the feeding of castings . . . Mr. Finch obtained his technical training from Wigan Technical College and the City and Guilds of London Institute for Foundry Practice . . . Began his industrial career with the Leyland Motor Co. Ltd., Leyland, England, as technical assistant . . . In 1943 joined K. L. Steelfounders & Engineering Co. Ltd., Letchworth and was named senior methods engineer . . . Later he was promoted to assistant foundry manager . . . Recently became associated with Catton & Co. Ltd., as foundry manager . . . His findings have been published in the British and American technical press and he has talked before various IBF branches as well as the IBF Annual Conferences . . . A member of the Institute of British Foundrymen and the Iron and Steel Institute.


W. W. Levi

Born in the city of Ann Arbor, Mich., Mr. Levi also graduated from the University of Michigan which is situated there . . . After receiving his chemical engineering degree he took postgraduate study in Europe at the Special School of Public Works, Paris, France . . . From 1926-34 was connected with Deere & Co., Moline, Ill., in the metallurgical laboratory . . . Transferred to Waterloo Iowa, plant of the Deere organization he remained there until 1931 . . . Has been chief metallurgist, Lynchburg Foundry Co., Lynchburg, Va. since 1934 . . . Has addressed a number of A.F.A. chapters on cupola operation.

NEW FOUNDRY LITERATURE

Reproduction of working diagrams, designs, legends or other line work on metals, plastics, plywood or pressed woods through the use of "Kodak Transfax," is the subject of a four-page folder obtainable from the industrial sales division of Eastman Kodak Co., 343 State St., Rochester 4, N. Y. Possible applications of the process in research and production are suggested. "Kodatrace," a new translucent tracing material described as an ideal medium on which to make drawings to be used in the "Transfax" process, is the subject of another new folder. The firm also offers a pamphlet designed to aid industrial organizations and photographic concerns, solve problems in "Storage of Microfilms, Sheet Films and Prints" of paper or safety film base—nitrate films are not covered.

Complete details regarding a new thermocouple of improved design and manufactured by Arklay S. Richards Co., Inc., 16 Winchester St., Newton Highlands 61, Mass., are available in Catalog No. 4, recently issued. Requests should be made on company letterhead.

Design features of its new zinc, lead and tin die casting machine are illustrated and discussed in a six-page folder offered by Light Metal Machinery, Inc., 736 Penton Bldg., Cleveland. Complete specifications of the machine are given, and the cycling mechanism in shown in a sequence of operation photographs.

Mechanized equipment for the foundry, designed to produce better, lower cost castings and suitable for applications ranging from heavy jobbing to mass production, is described in "Foundry Mechanization," a new 20-page booklet available from Allis Chalmers Mfg. Co., Milwaukee 1. Shakeouts, sand conditioning and reclaiming machinery, motors, drives, controls, cupola blowers and mercury arc converters, are included in the line discussed in the booklet, Bulletin No. 07B6092A. In another new publication, Bulletin 25B6150, titled "More Power to U.S.A.," the firm presents its equipment for power generation and transmission, including blowers, compressors, auxiliary motors, switch gear and power transformers.

Hills-McCanna Co., 3025 N. Western Ave., Chicago 18, has issued a handsomely illustrated, 52-page booklet on magnesium alloy castings. Contents include a general discussion of the nature of the metal and its uses; data on physical properties, alloy specifications and the action of chemicals on magnesium; a pictorial presentation of the company facilities and a discussion of its products; information on designing, riveting, welding, machining, finishing and testing magnesium products, and notes on foundry practices.

Peters-Dalton, Inc., 17900 Ryan Road, Detroit 12, has issued two technical bulletins; No. 101, "Hydro-Whirl Dust Collectors," and No. 201, "Hydro-Whirl Spray Booths," which are the first in a line of technical booklets designed to supply the industrial engineer with pertinent data and simplified selection methods. Requests for copies should be on company letterheads and should bear the title of the writer.

Rods for low temperature welding of cast iron, steel, stainless steel and various non-ferrous alloys; a galvanizing powder for cast iron; brazing compounds, and fluxes, all products of All-State Welding Co., 96 West Post Road, White Plains, N.Y., are described in a 32-page booklet available from the firm. The booklet also discusses advantages of low temperature welding, and serves as an instruction manual and catalog on the company products.

Publication of a new 64-page general welding and cutting products catalog has been announced by Air Reduction Sales Co., 60 East 42nd St., New York 17. Subject matter is divided into two sections, one dealing with oxyacetylene welding and cutting gases, equipment and supplies; the other, with arc welding machines, accessories and electrodes. Final ten pages list prices.

Cupolas, cupola accessories, sandblast machines, tumbling barrels, dust collectors and a magnetic separator, are included in the line of foundry equipment discussed and shown in a new bulletin, No. 475, released by Tabor Mfg. Co., 6225 Tacony St., Philadelphia 35.

Racine Steel Castings Co., a division of Belle City Malleable Iron Co., Racine, Wis., has issued the third in a series of attractive folders directed toward promotion of greater cooperation between the design departments of machine manufacturers and the foundry. The current folder, "A Case in Casting Redesign," stresses, as did the others, that such cooperation is calculated to result in the best possible—and most economical—casting for a given part.

Publication of a new, informative booklet, "Cutting Tool Materials," analyzing the fields of usefulness of high speed steels, cast alloys and carbides as cutting tools, has been announced by Allegheny Ludlum Steel Corp., 2020 Oliver Bldg., Pittsburgh, Pa. Foundrymen, who use cutting tools in milling, cleaning and machining of castings, will be interested in this conveniently organized comparison of basic characteristics, properties and functions of three cutting materials, which simplifies evaluation of their usefulness for specific applications.

Design features, specifications and models of "D'Oiler" degreasers, are attractively presented in an eight-page two-color booklet, by Mechanical Process Co., South Orange, N. J. Models shown cover a wide range of applications, from large-capacity floor units to the small, bench type for the laboratory, and for cleaning small, complex parts, heavily contaminated work, or stubborn jobs requiring force spray.

In a new descriptive folder, Arcos Corp., 1515 Locust St., Philadelphia 2, describes the "Orcos Oxyarc Process" for hand cutting or piercing cast iron, stainless steel, alloy steel and non-ferrous metals. The new process, developed for application wherever A.C. or D.C. welders and bottled oxygen are available, is diagrammatically represented and explained.

Associated Safety and Claims Service, Inc., 123 William St., New York 7, has issued a 16-page compilation of case histories, illustrating the 38 per cent savings on workmen's compensation averaged by companies using the A.S.C.S. Plan in their organizations.

Applications of Diesel-powered tractors to a wide variety of tasks where mobile, flexible power is required by industrial plants, are stressed in a new 20-page booklet, "Caterpillar Diesels at Work in Industry," offered by Caterpillar Tractor Co., Peoria 8, Ill.

"Automatic Temperature Control Systems," Educational Bulletin No. 5, released by Wheelco Instruments Co., 847 Harrison St., Chicago 7, explains measurement and automatic control and the selection of the proper control systems for process applications, and incorporates charts, tables and diagrams. ASME terminology on the subject is appended.

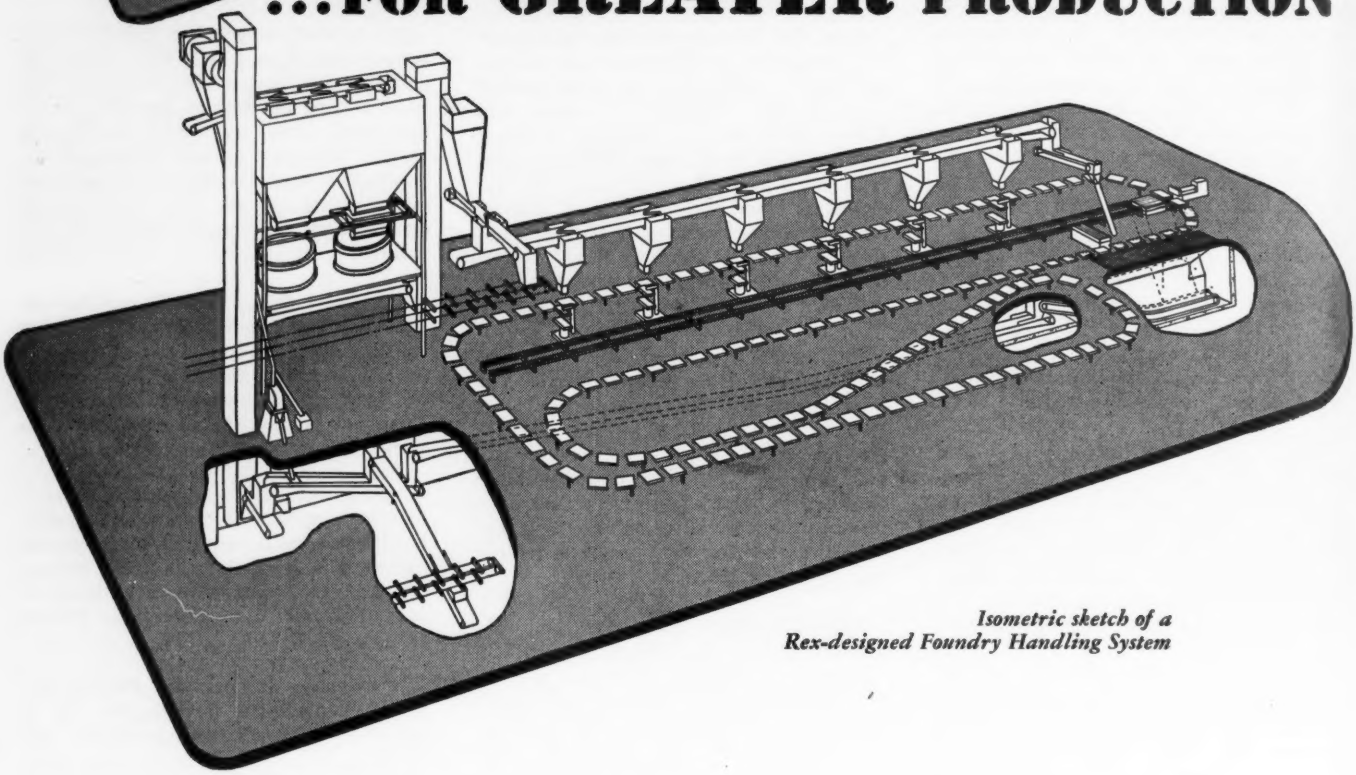
Performance data, specifications, outline dimensions and features of the new "Power Jacklift," manufactured by Lewis-Shephard Products, Inc., 325 Walnut St., Watertown 72, Mass., are presented in an eight-page illustrated booklet recently issued by the firm.

Electric overhead traveling cranes are described in a new 28-page booklet issued by Victor R. Browning & Co., Inc., Mentor Ave., Willoughby (Cleveland), Ohio. Descriptive information on brakes, hook blocks, cages, motors, clearance table for cranes, rebuilding of cranes, buckets and trolleys are included.

Synchronous motor starters for 600 volts or less, and for 2300-4600 volts, are described in new bulletins, Nos. 1075-B, 1076-B, 1077-A, 1078-A, available from Electric Controller & Mfg. Co., 2700 E. 79th St., Cleveland 4.

PATTERN

...FOR GREATER PRODUCTION



Isometric sketch of a
Rex-designed Foundry Handling System

Large foundry or small, the pattern for increased capacity is an efficient Rex Foundry Handling System. By bridging the gaps between foundry operations . . . the handling and reconditioning of sand . . . the conveying of molds . . . the moving of castings, a continuous production flow is assured that permits the greatest output at lowest cost per square foot of floor space.

Rex Foundry Handling Systems, individually engineered to fit each job, will insure increased output, eliminate unnecessary handling and reduce the cost of indirect labor. Foundry-trained engineers will be glad to design and install a capacity-increasing, cost-cutting system . . . a system that will not only mean more profit but good employee relations by cutting worker fatigue. For all the facts, write Chain Belt Company, 1725 W. Bruce St., Milwaukee 4, Wisconsin.

REX FOUNDRY HANDLING SYSTEMS
CHAIN BELT COMPANY OF *MILWAUKEE*

CONVINCING EVIDENCE OF *G-IRON SUPERIORITY

Photomicrograph 100 diam. unetched. Regular pig—Silicon 2.40, Total Carbon 4.04.

Photomicrograph 1000 diam. etched. Regular pig—Silicon 2.40, Total Carbon 4.04.

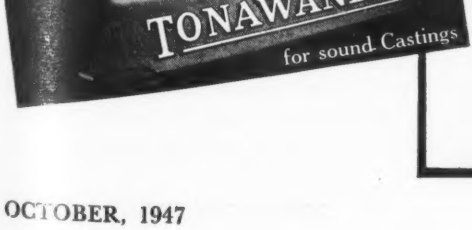
Photomicrograph 100 diam. unetched. G-Iron pig—Silicon 2.35, Total Carbon 4.10.

Photomicrograph 1000 diam. etched. G-Iron pig—Silicon 2.35, Total Carbon 4.10.

Examine closely this photograph of two pigs. Notice the refinement of grain structure of the *G-Iron pig (right) as compared with the regular pig (left).

Now inspect the photomicrographs which correspond with each pig...*convincing evidence of *G-Iron superiority.*

*G-Iron is graphitized pig iron. A patented blast furnace process refines the grain structure of the pig—and this refinement follows through to the final casting. The finely distributed graphite increases fluidity and reduces chill in thin sections—improves machinability and helps to overcome shrinkage and porosity between thin and heavy sections.



TONAWANDA IRON CORPORATION

NORTH TONAWANDA, N. Y.

Division of AMERICAN RADIATOR & Standard Sanitary CORPORATION

CONFERENCE

(Continued from Page 27)

National Director E. N. Delahunt, Warden King, Ltd., Montreal, also addressed the members and guests of the chapter on association activities.

Saturday morning G. D. Turnbull, vice-president, Shawinigan Foundry, Ltd., Shawinigan Falls, Que., acted as chairman for the iron group session. Speakers were: E. N. Delahunt, general superintendent, Warden King, Ltd., and J. S. Morse, assistant foundry superintendent, Canadian Ingersoll Rand Co. Ltd., Sherbrooke. The former had as his subject "Cupola Operation" and the latter "Melting of Cast Iron in the Electric Furnace."

In reporting on the operation of the cupola it was pointed out by Mr. Delahunt that proper lighting of the cupola bed and bed height had a preponderant effect upon successful cupola operations. The speaker's discourse featured a step-by-step account of lighting up the cupola as per the practice in his shop. In his paper Director Delahunt also referred to the necessity of having dry cupola linings.

Batch coal, continuous coal and duplexing were the three methods of melting cast iron as described in the first part of Mr. Morse's paper. However, the author, being familiar with direct arc melting practice, discussed this fully including melting capacities of electric furnaces, voltages used, regulators, refractories and typical furnace charges.

Members of the steel group heard two papers; one on "Determination of Risers for Steel Castings" and the other on "Alloy Additions for Steel Castings." Mr. Robert Stott, Canadian Car & Foundry Ltd., Montreal, was the steel chairman. Authors of the above papers were W. T. Shute, general foundry foreman, Canadian Car & Foundry Ltd., Longue Pointe Works and R. T. Thompson, metallurgist, Canadian Car & Foundry Ltd., respectively.

In aiding the determination of the type of riser to be used on steel castings, Mr. Shute referred to the formula surface area vs. volume. To show the practical application of this formula he brought to this

(Concluded on Page 83)

CONFERENCE

(Continued from Page 80)

meeting a casting made in his shop. An array of photographs showed further use. Mr. Shute concluded his talk by commenting on exothermic additions to risers and feeding characteristics.

Basis for R. T. Thompson's treatise was ASTM specification A-128—alloy additions to steel. Commenting upon his own shop's practice he cited instances where vanadium and nickel are used to increase ductility in high and medium strength steels. Manganese, chromium and molybdenum are used as grain coarseners. A 1650° heat treatment is given most of the commercial steels with special care given to alloy steels. The speaker also included in his talk the alloys added to steel to obtain the new revised ASTM specifications.

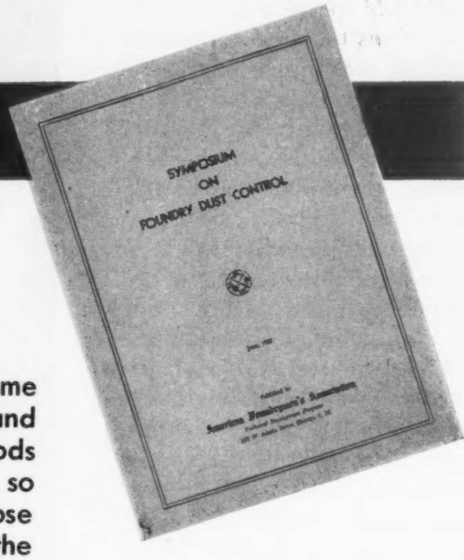
The Eastern Township Committee, which was accorded a special vote of thanks for its highly successful arrangements, was headed by G. M. Young, Canadian Ingersoll Rand Co. Ltd. The other members of the committee included E. Fisette, Canadian Fairbanks Morse Co. Ltd.; J. C. Kinsella, Union Screen Plate Co. of Canada Ltd.; Wilfred Legare, La Fonderie Legare; R. Neville, Manganese Steel Castings Ltd.; and E. F. Patten, Canadian Brake Shoe & Foundry Co., Ltd.

The Montreal Committee was under the chairmanship of James H. Newman, Chamberlain Engineering Ltd., and A. H. Lewis, Dominion Engineering Works, as secretary. The rest of the committee consisted of Chapter Vice-Chairman O. L. Voisard, Robert Mitchell Co.; A. J. Moore, Montreal Bronze Ltd.; J. Grieve, E. F. Clark and J. G. Hunt, Dominion Engineering Works; M. A. Hughes, La Salle Coke Co.; Wm. Seeds, Western Pattern Works, W. S. Williams, Canadian Car & Foundry Ltd.; Wm. Nuttall, Warden King Ltd.; Paul Savoie, Webster & Sons Ltd.; and John McVey, Jenkins Bros. Ltd.; all of Montreal.

Among the foundry shops in Sherbrooke which were visited by parties of foundrymen during the conclave were: Union Screen Plate Co. of Canada Ltd.; Canadian Fairbanks Morse Co. Ltd.; and Canadian Ingersoll Rand Co. Ltd.

Presenting A WEALTH OF AUTHORITATIVE

DATA ON **MODERN FOUNDRY** DUST CONTROL!



Dust problems in the foundry have become more complex because of accelerated production, new methods and materials, the labor market and scarcity of materials. New methods and materials have resulted in diversification of foundry dusts so that they now include those classified as hazardous down to those which are just plain nuisances . . . points which are covered in the newest symposium released by the American Foundrymen's Association.

FOUNDRY DUST CONTROL

. . . a symposium comprising papers by six outstanding authorities on the control of foundry dust . . .

$1.00 to AFA members — $2.50 to non-members.

This 32-page, 8 ¼ by 11 ¼, paper-bound booklet includes practical articles sponsored by the AFA Safety and Hygiene and Plant and Plant Equipment Committees:

"Hoods and Piping for Foundry Dust Control Systems"—E. A. Carsey

"Centrifugal Dust Collectors"— H. C. Dohrmann

"Cloth Type Dust Collectors"— G. A. Boesger

"Wet Type Dust Collectors"— A. S. Lundy

"Fans and Exhausters"—P. Cohen

"Maintenance of Foundry Dust Control Equipment"—K. M. Smith

Be sure this handy reference material, dealing with dust control in modern foundry practice—design . . . engineering recommendations . . . performance . . and equipment maintenance—is included in your foundry library. Don't delay—send for your copy of "Symposium on Foundry Dust Control" today.

American Foundrymen's Association
222 West Adams, Chicago 6, Illinois

Please send me . . . . . . *copies of* Symposium on Foundry Dust Control. *Remittance of $*. . . . . *is enclosed.*

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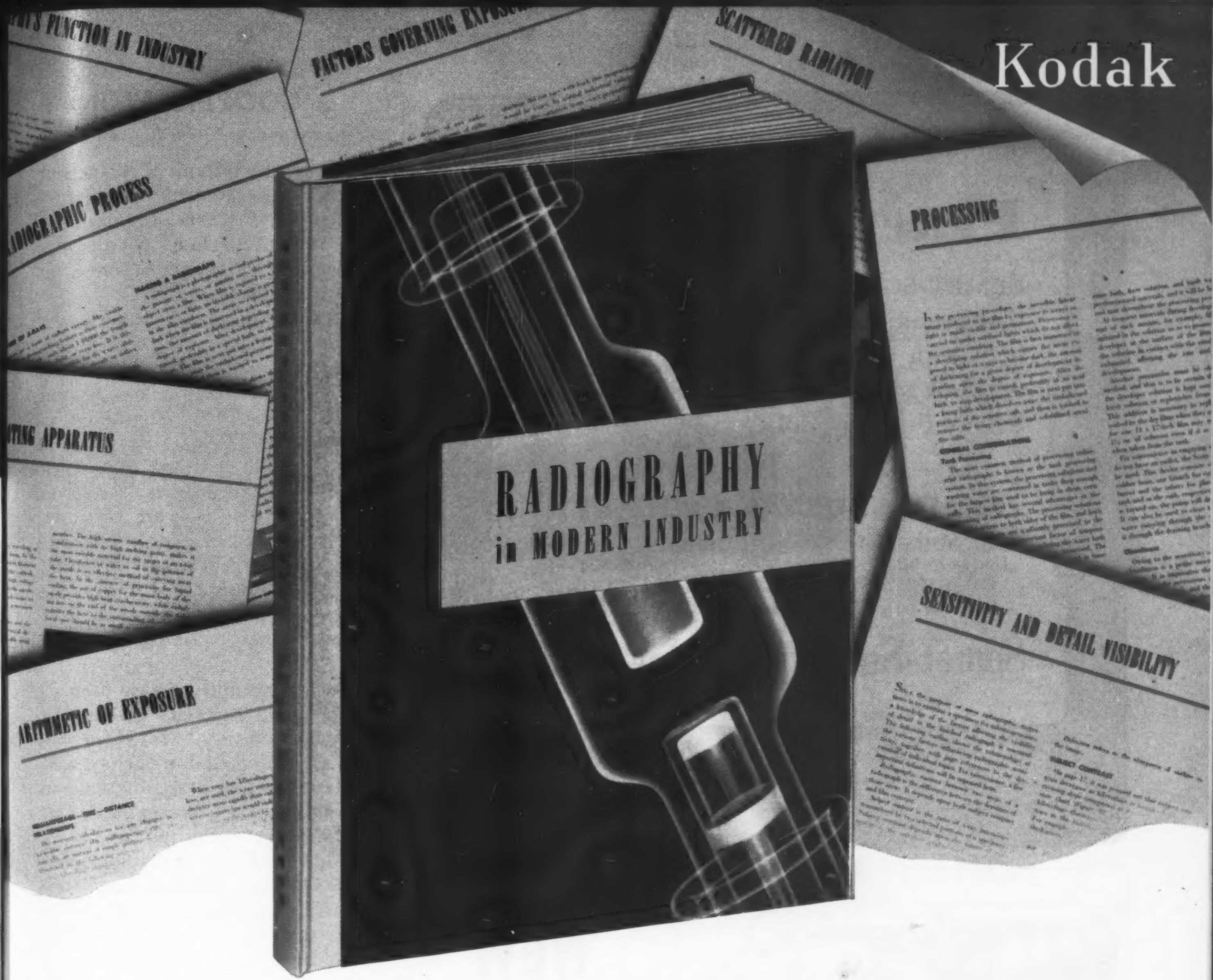
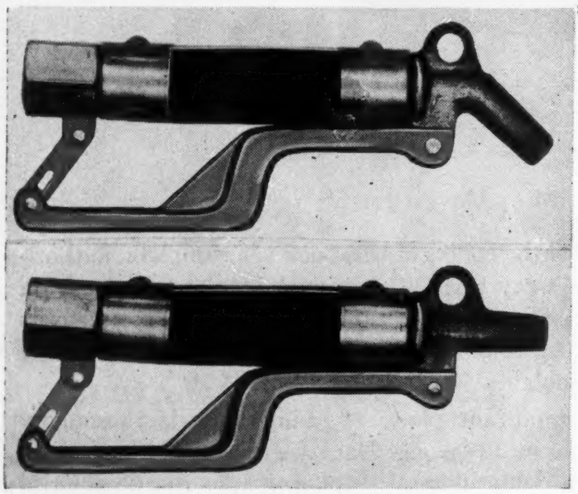

Kodak
SCATTERED RADIATION
PROCESSING
SENSITIVITY AND DETAIL VISIBILITY
ARITHMETIC OF EXPOSURE
RADIOGRAPHY
in MODERN INDUSTRY



COOPERATION

(Continued from Page 43)

tries produce billions of component parts, and in hundreds of thousands of designs, each year. For example, one malleable foundry produces 3,000 different designs for one of its many consumers."

In the foundry, as in other manufacturing plants, Mr. Reese explained, some complex parts require many processing operations. "If you schedule part 'A,' which is simple to process, before part 'B,' which is complex," he pointed out, "then your shipping schedules are going to be interrupted or you are inventorying unwanted materials." Consequently, the speaker said, foundries are continuously asked to take one part out of production and put in its place another, more urgently needed.

Such interruptions have been accepted as a necessary evil by the foundry industry, Mr. Reese observed, adding, "I don't believe anyone could assign a tangible value to the discounting effect on the overall performance of this industry, but I would hazard a guess that the difference between precision and interrupted scheduling would amount to more than five per cent in foundry performance figures."

Concerning other aspects of the relationship between consumer demands and efficient foundry operation, Mr. Reese said: "If your patterns are not rigged for quantity production or are not kept in 'A-1' condition, or if you are trying to make one pattern do where two would make it possible to meet your procurement requirements, then you are playing a significant part in foundry production performance.

"The foundry process of manufacture is not a stable thing. It has made considerable progress in the past 20 years, and its rate of progress in the next several years is likely to be greatly accelerated. It is quite possible that increasing knowledge at the foundry level gravitates back to you in the form of a request to spend money on pattern changes.

"These changes may be intended to achieve better design, production or dimensional tolerance, or freedom from distortion, etc. It is most

(Concluded on Page 88)

COOPERATION

(Continued from Page 86)

likely that your foundry suppliers have been in business a long time, and expect to continue; so I would urge you to give them a fair hearing on requests of this type, for you are intended to be the principal beneficiary in the long run."

Surveying recent productions figures for gray and malleable iron castings, Mr. Reese expressed the opinion that the availability of gray iron castings may improve within the next few months, while that of malleable castings will probably remain at the present level. He also analyzed the supply situation in coke, pig iron and scrap, and predicted that foundries would maintain current melting tonnages in spite of difficulties in regard to those materials.

Concluding, he told the purchasing agents: "I would like to point out that the malleable iron industry has been established in this country since 1815; the gray iron industry, since Revolutionary days. Just as these industries have played a significant role in the American scheme of things for the past 130 to 170 years, so do they look forward to the future with a desire to play an increasingly important part in industrial progress.

"Currently, you have grave concern about procurement, availability of raw materials and continuously increasing costs. The gray and malleable iron industries are equally concerned."

Furnace Association Sponsors Contest

In a desire to promote the publication of more and better technical articles describing the economic advantages obtained by the use of modern industrial furnaces, kilns and ovens the Industrial Furnace Manufacturers Association, Inc., 420 Lexington Ave., New York 17, is sponsoring a contest. The IFMA will award prizes amounting to $1500 for the three best articles appearing in the trade press during October 1, 1947 to September 30, 1948 inclusive. Further details concerning rules and regulations of the contest can be obtained from the furnace association.

McElwee Appointed Gray Iron Chairman

R. G. McElwee, foundry alloy division manager, Vanadium Corp. of America, Detroit, has been elected Chairman of the gray iron division of the American Foundrymen's Association.

Chosen Vice-Chairman of the division at its annual business meeting early this year, Mr. McElwee now succeeds Russell J. Allen, metallurgical engineer, Worthington Pump & Machinery Corp., Harrison, N.J. Mr. Allen, long active in national technical groups of A.F.A. and 1947 recipient of the A.F.A. John A. Penton gold medal, was elected gray iron division chairman this year. He has resigned because of ill health.

Prior to his election as division Vice-Chairman, Mr. McElwee served as head of the Cupola Research Project and as Vice-Chairman of the programs and papers committee.

Elected Vice-Chairman, to fill the office vacated by Mr. McElwee, was V. A. Crosby, Climax Molybdenum Co., Detroit. Known widely for his papers and technical reports on gray iron castings, Mr. Crosby has been affiliated with the gray iron division for a number of years. During this time he has served on the following division committees: executive, advisory, program and papers, subcommittee on engineering properties symposium and various others.

A native of Kosciusko, Miss., he has been identified with the foundry industry for 30 years. He began his career with Dodge Bros. Motor Co. Detroit; has also been associated with Packard Motor Car Co., Detroit and Studebaker Corp., South Bend, Ind. Since 1934 has been with Climax Molybdenum.

December Deadline For '48 Convention Papers

Technical papers for the 1948 Annual Convention of the American Foundrymen's Association, to be held in Philadelphia May 3-7, are now being considered by the Association's eight technical divisions in the fields of gray iron, steel, malleable iron, brass and bronze, aluminum and magnesium, patternmak

ing, sand and education. General interest committees on safety and hygiene, plant equipment, foundry costs, castings inspection, refractories and time study and job evaluation are also selecting papers.

Authors are urged to submit their papers as soon as possible, since none will be scheduled for the 1948 convention unless approved by the appropriate Program and Papers Committee prior to January 15, 1948. They must be submitted to a division review committee before December 15, 1947. Other features of the publication policy approved by the A.F.A. Board of Directors include preprinting and distribution of all convention papers prior to the convention, to promote active discussion on the convention floor. Editorially suitable papers also will be printed in AMERICAN FOUNDRYMAN.

The forthcoming convention, 52nd Annual Meeting of A.F.A., will be held in Philadelphia. Occurring in an exhibit year, it will feature the growing emphasis on mechanization and plant improvements of all kinds for purposes of more economical operation and quality products. There is much to indicate that the technical program of sessions, shop operation courses and the popular informal round-table luncheons will be of greater interest to foundrymen through improved quality of papers and sessions.

Papers for the meeting may be submitted to the Technical Director, American Foundrymen's Association, 222 West Adams St., Chicago 6, Ill.

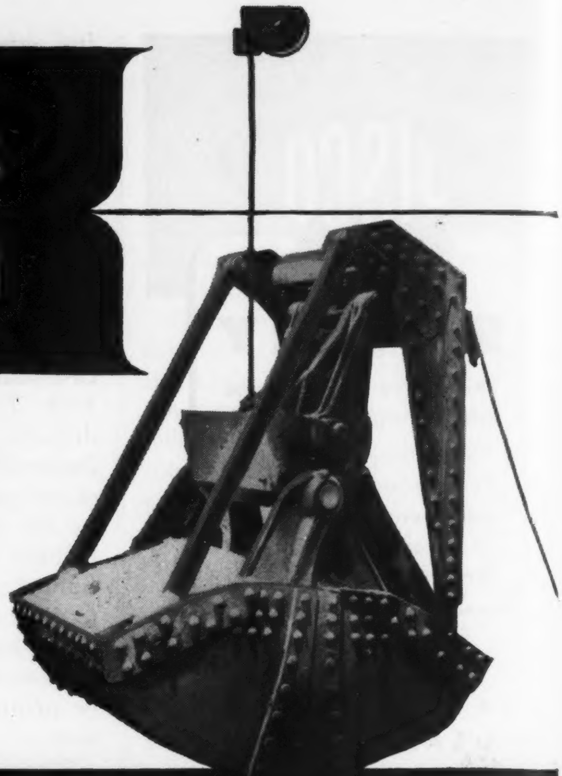
Ontario Chapter Repeats Foundry Course

LAST YEAR's course in foundry fundamentals will be repeated this season according to R. H. Williams, superintendent of foundries, Canadian Westinghouse Co., Ltd., Hamilton, who is Chairman of the Ontario chapter Educational Committee.

Starting September 29, the course runs for 24 weeks, one night per week. The course is under the direction of Willard Jones, metallurgist, Canadian Westinghouse Co., Ltd.,

(Concluded on Page 93)

JUST 6 FEET 7 INCHES OPERATING HEADROOM

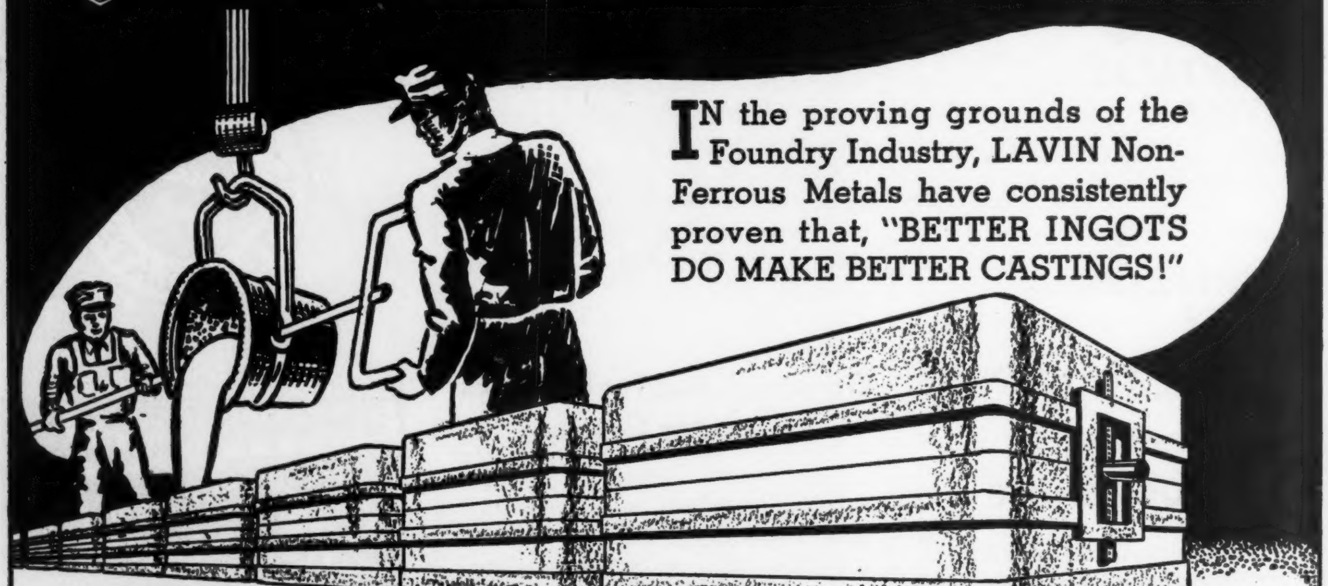


You may not require a bucket of such extremely low headroom, but if you do, Blaw-Knox makes it. It's just one of many designs particularly suited to foundry conditions which are illustrated and fully described in *Catalog 2002*. Your request will bring a copy by return mail.

BLAW-KNOX DIVISION
of Blaw-Knox Company
2073 Farmers Bank Bldg., Pittsburgh 22, Pa.

BLAW-KNOX CLAMSHELL BUCKETS

"*Better* INGOTS *make Better* CASTINGS"



IN the proving grounds of the Foundry Industry, LAVIN Non-Ferrous Metals have consistently proven that, "BETTER INGOTS DO MAKE BETTER CASTINGS!"

LAVIN *Brass, Bronze . . . Aluminum* INGOT

R. LAVIN & SONS, INC.
Refiners of Brass, Bronze and Aluminum
3426 SOUTH KEDZIE AVENUE · CHICAGO 23, ILLINOIS
REPRESENTATIVES IN PRINCIPAL CITIES

FOUNDRY COURSE

(Continued from Page 91)

who planned and taught the course last year. Costing only $5, the classes are held at Hamilton Technical School.

The course in foundry fundamentals resulted from an early 1946 Ontario chapter board of directors meeting. The Directors charged Robert Robertson, malleable foundry superintendent, International Harvester Co., Ltd. and M. N. Tallman, assistant superintendent, A. H. Tallman Bronze Co., Ltd., with the task of organizing the course.

The response of foundry managers and superintendents to a questionnaire indicated a general need for an elementary foundry course for young men working in the foundries. The course in fundamentals received strong backing from foundry management.

Designed to include the fundamentals of all types of foundry practice, the course covers gray iron, steel, malleable iron, brass and bronze, and the light metals. Subjects covered include: sand testing and control; ferrous and non-ferrous metallurgy; melting; patterns and pattern equipment; molding; core sands and core making; gating and risering.

Casting Defects Book Going to Press

THE BOOK ANALYSIS OF CASTING DEFECTS, which is the result of seven years study by a number of experienced foundrymen, is going to press and first copies of the publication are expected to be available sometime in November. Thirty-one basic casting defects are listed and described. Defects are defined simply and completely and illustrated by 100 photographs collected from U. S. foundries and Canada.

Originally intended for gray iron foundries and prepared by men associated with the gray iron field, this book will be valuable to all foundrymen. Only four of the defects described are peculiar to gray iron.

The list of defects is shorter than the original number (see p. 16, November, 1941, AMERICAN FOUNDRYMAN). Many of the defects originally listed were found to be basically the same; these have been combined and are now listed as one defect. The object of the committee has been to find the basic defects and then outline the fundamental causes. It is only by eliminating the fundamental cause or causes that a defect can be eliminated.

The final committee responsible for the preparation of ANALYSIS OF CASTING DEFECTS consists of:

Chairman, W. A. Hambley, Falls Mfg. Co., Menomonee Falls, Wis.

Secretary, A. S. Klopf, The Western Foundry Co., Chicago.

G. W. Anselman, Goebig Mineral Supply Co., Chicago.

T. E. Barlow, Eastern Clay Products, Inc., Jackson, Ohio.

E. J. Carmody, C. C. Kawin Co., Chicago.

W. B. McFerrin, Electro Metallurgical Co., Detroit.

F. L. Overstreet, Illinois Clay Products Co., Chicago.

Charles Zahn, Vilter Mfg Co., Milwaukee.

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